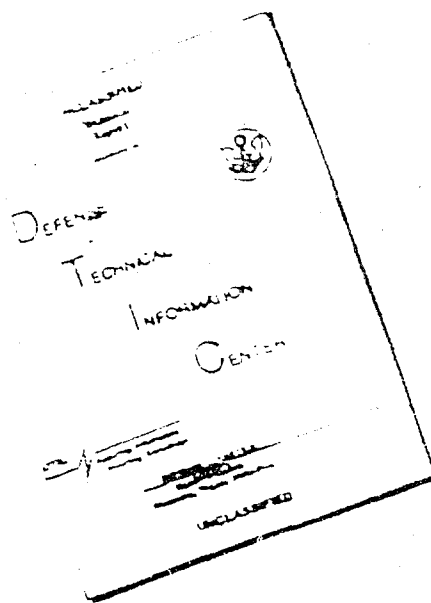


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Mk 81 AND Mk 82 BOMB RELEASE CURVES

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ABSTRACT: A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves. The curves presented are not intended to replace the ballistic table but rather to present them in a more usable form for the fuze designer and analyst.

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18 May 1966

Mk 81 and Mk 82 Bomb Release Curves

This report contains the release envelopes for the Mark 81 and Mark 82 bombs in both the retarded and unretarded modes. This work was performed under Bureau of Naval Weapons WEPTASK RM37 73002/212 1/S470 BC 02, Problem Assignment 1, Bomb and Air Rocket Fuze Fleet Support.

J. A. DARE
Commander

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R. E. GRANTHAM
By direction

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REFERENCES

- (a) NWL ltr KEB:PES:jcs 8150/B of 2 Jan 1965 to Eglin AFB,
Subj: Exterior Ballistic Data for Bomb Mark 81/
Snakeye/ Mech Nose Fuse/ FF, Bomb Mark 82/ Snakeye I/
Mech Nose Fuse/ FF, Chemical Bomb Mark 116 Mod 0
- (b) NWL rpt NWL Table No 05-64-011 of May 1964, Ballistic
Tables (Interim) for Bomb Mark 81 Mod 1 with Bomb Fin
Mark 14 Mod 1/ Retarded (Snakeye 1) Range and Time of
Fall Level and Dive
- (c) NWL rpt Ballistic Table No 010 of Oct 1964, Bomb Mark 82
Mods 0 & 1 with Bomb Fin Mark 15 Mod 0/ Retarded
(Snakeye I), Range and Time of Fall Level and Dive Zero
Ejection Velocity

INTRODUCTION

1. The purpose of this study is to aid in the determination of what delivery conditions can be used to hit a target with the Mark 81 and Mark 82 bombs in either the retarded or unretarded modes. The study is also concerned with the tactics that the delivery aircraft uses after releasing the bomb, in that the recovery altitude of the aircraft under a given set of release conditions is also investigated. Several questions which this report attempts to answer are:

a. For a given release velocity, release (dive) angle, and altitude:

(1) At what horizontal distance from the target should the bomb be dropped in order to hit the target?

(2) At what altitude will the aircraft be able to recover from its dive?

(3) What is the time of fall of the bomb?

b. For a given velocity, angle, and pullout recovery altitude:

(1) At what altitude should the bomb be released?

(2) At what horizontal distance from the target should the bomb be dropped?

(3) What is the time of fall of the bomb?

MATHEMATICAL METHOD

2. To determine the release envelopes of a given bomb a set of release conditions, such as release velocity, bomb ejection velocity, and release angle, must first be chosen. An arbitrary set of release altitudes is now selected and under the given release conditions the corresponding time of fall and horizontal distance of bomb travel during fall is determined. To hit a given target, a bomb that is released at one of the arbitrary altitudes must also be at the determined horizontal distance from the target. For a given set of release conditions, the set of release altitudes is plotted against their corresponding horizontal distance from the target. On each graph (Figures 1 through 108) a series of these altitude vs. horizontal distance curves is plotted; one curve for each release (dive) angle.

Time is regarded as a parameter on these release curves. In addition to determining the horizontal distance of bomb travel, the time of fall of the bomb is also determined for each member of the set of release altitudes. By interpolation between these determined values of the time of fall, a point on each release curve for which the bomb will have a given time of fall can be located. In this way constant time of fall curves can be drawn of each graph.

3. For a given altitude the horizontal distance the bomb travels is determined by solving a set of simultaneous differential equations. The equations of motion:

$$\ddot{X} = D\dot{X}$$

$$\ddot{Y} = D\dot{Y} - g$$

where

\dot{X} = the horizontal velocity of the bomb

\ddot{X} = the horizontal acceleration of the bomb

\dot{Y} = the vertical velocity of the bomb

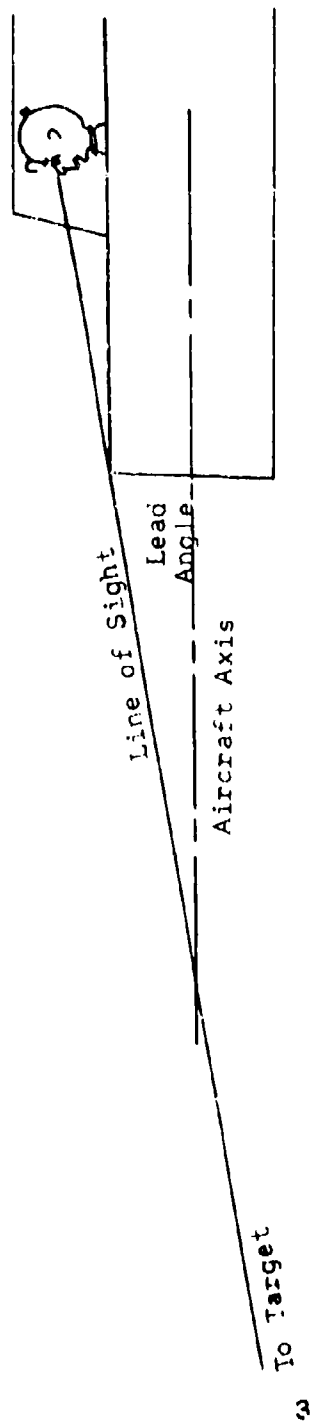
\ddot{Y} = the vertical acceleration of the bomb

are written with the assumption that the only forces acting on the bomb are due to drag (D) and gravity (g). Drag is assumed to be acting in the opposite direction of the velocity vector, and gravity is assumed to be varying with altitude.

4. The drag coefficient of the Mk 81 and Mk 82 bombs in the unretarded mode was obtained from reference (a). The drag coefficient of the Mk 81 and Mk 82 bombs in the retarded mode was obtained from equations in reference (b) and reference (c) respectively. Atmospheric properties are determined by using the 1959 ARDC model atmosphere.

5. Each set of release conditions yields a release curve, and a given release altitude determines a release point on this curve. There exist certain conditions which limit the release altitudes and as a result restrict the possible release points to a segment of the release curve. One of these conditions is the lead angle which is the limiting angle between the line of sight from the pilot to the target and the aircraft axis. (See following illustration.) Each release curve may have at most one limit point induced by the lead angle. By joining the lead angle limit points we can obtain a curve of

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limit points corresponding to this lead angle. If the release angle is sufficiently large, the release curve corresponding to this release angle and all release curves for larger release angles will not have lead angle limit points.

6. Another limiting conditions on each release curve is the recovery altitude of the aircraft for a given pullout. The release altitude A corresponding to pullout at altitude H is calculated by the following equations: (See following illustration.)

$$A = V \cdot T \cdot \sin \phi + D + H$$

where

V = release velocity of the bomb, i.e., aircraft velocity

T = the delay in time when the pilot initiates pullout and when pullout actually begins

ϕ = release angle

D = the loss in altitude during pullout which is given by the following equation:

$$D = \frac{V^2}{32.0} \left(\frac{1}{G-1} - \frac{\cos \phi}{G - \cos \phi} \right)$$

where

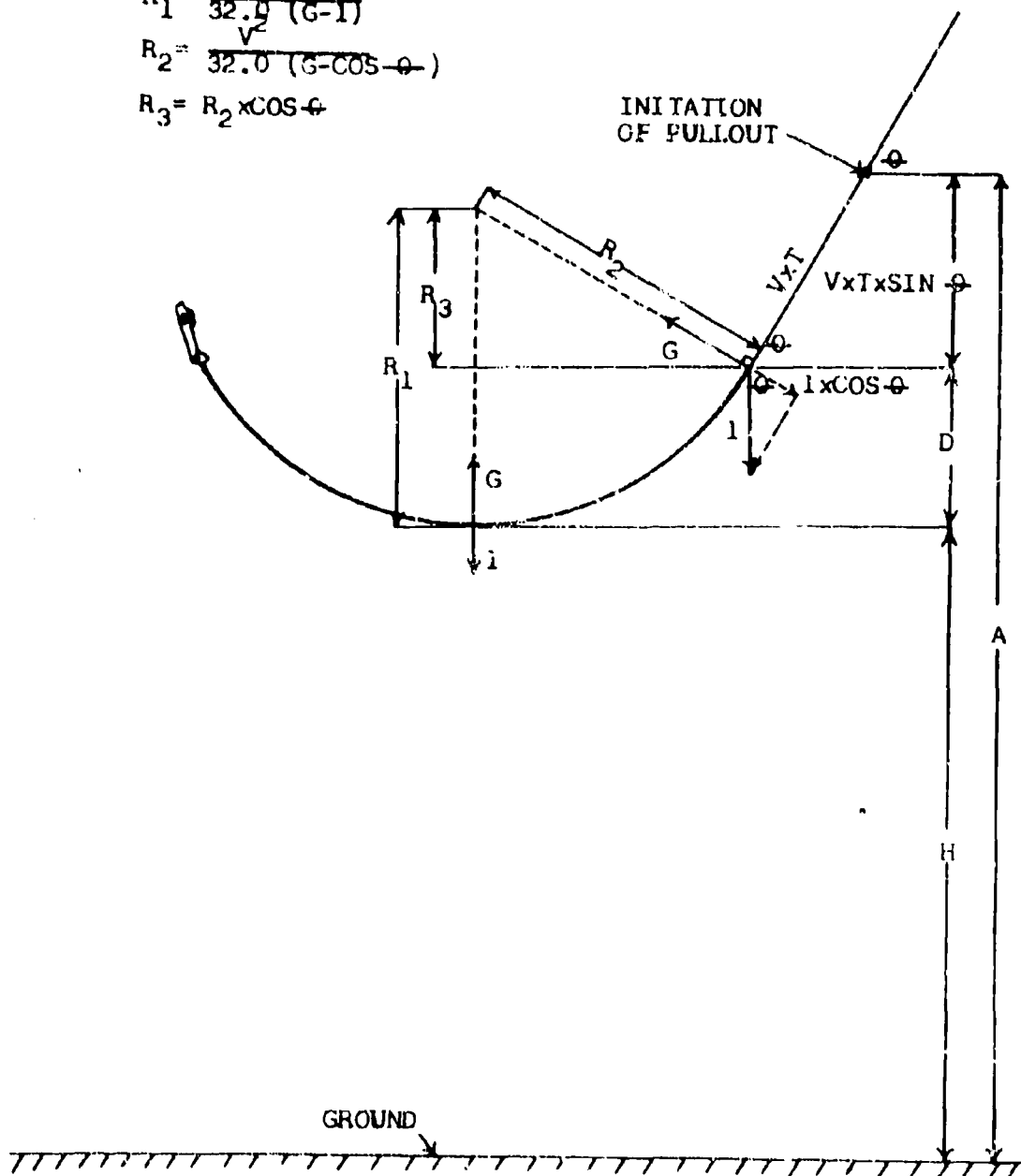
G = number of g's experienced by the pilot during pullout.

The range corresponding to release at altitude A is determined by interpolation on the release curve. By joining the limit points on each release curve corresponding to a recovery altitude H a pullout curve can be determined for a given set of release velocity, ejection velocity, and number of g's during pullout. By using different values of H, a series of pullout curves can be plotted on each graph.

EXPLANATION OF GRAPHS

7. The release curves for the Mk 81 and Mk 82 bombs are given for release velocities (speeds) varying from 200 to 600 knots in 50-knot increments and for 2.0g and 4.0g pullout. Release curves are given for ejection velocities of 0 and 10 fps in the retarded mode and for 10 fps only in the free fall (unretarded) mode. Figures 1-36 are the Mk 81 retarded release curves, Figures 37-72 are the Mk 82 retarded release curves, Figures 73-90 are the Mk 81 unretarded release curves, and Figures 91-108 are the Mk 82 unretarded release curves.

$$R_3 = R_2 \times \cos \phi$$



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8. There is an error in Figures 1-72. On these curves the point corresponding to a release angle of 0 degree and a release altitude of 50 feet is incorrect. Table 1 is a table of corrections for these graphs. The values of horizontal range in this table should be used instead of the points indicated on the graphs for 50-foot altitude and 0-degree angle and the segment of the 0-degree release curve between 0 and 100-foot altitude should be adjusted to account for the corrected value.

9. On a given graph there are 5 variables that are considered: release angle, release altitude, horizontal distance of bomb travel, time of fall, and pullout altitude. If 2 of these variables are known the other 3 can be determined. On the graphs it is assumed that pullout is initiated as soon as the bomb is released and that there is a 2.25-second delay between the time when the pilot initiates pullout and when pullout actually begins. The best way to explain how the curves are to be used is through several illustrative examples.

a. Example 1:

Given:

- (1) Bomb - Mk 82
- (2) Mode - retarded
- (3) Ejection velocity - 10 fps
- (4) Release velocity (speed) - 450 knots
- (5) Release angle - 20 degrees
- (6) Release altitude - 1200 feet

Find:

- (1) Horizontal distance of bomb travel
- (2) Time of fall of the bomb
- (3) Minimum recovery altitude for a 2.0g and 4.0g pullout.

Given quantities (1) through (4) indicate that Figure 60 or 69 should be used. Figure 60 corresponds to 2.0g pullout, Figure 69 to 4.0g pullout. We locate the point on the 20-degree dive angle curve which corresponds to a 1200-foot

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release altitude. The horizontal distance (range) the bomb will travel is 2235 feet. The time of fall is between the big dash lines representing 5 and 6 seconds or approximately 5.7 seconds. Using Figure 60 it can be seen that the recovery altitude during a 2.0g pullout is less than zero, for no pullout recovery altitude curves intersect the 20-degree curve; therefore, for a 2.0g pullout this run cannot be made. For a 4.0g pullout Figure 69 is used and the minimum altitude during pullout; i.e., the pullout recovery altitude, is approximately 145 feet. If one desired to pullout at a greater altitude, i.e., 200 feet, this drop could not be made at 1200 feet.

b. Example 2:

Given:

- (1) Bomb Mk 81
- (2) Mode - retarded
- (3) Ejection velocity - 0 fps
- (4) Release velocity (speed) - 300 knots
- (5) Release angle - 10 degrees
- (6) Safe arming time of the fuze - 5 seconds

Find:

- (1) Minimum release altitude so that the bomb will hit the target and be armed before impact
- (2) Recovery altitude for the aircraft using 2.0g and 4.0g pullout.

Given quantities (1) through (4) indicate that Figure 3 or Figure 12 should be used. Using Figure 3 the intersection of the 5-second time-of-fall curve and the 10-degree dive angle release curve is located. The bomb can be dropped from any altitude above 560 feet; i.e., 560 feet is the minimum release altitude that can be used to hit the target and have the bomb fuze armed before impact. Using Figure 3 the recovery altitude corresponding to this minimum release altitude of 560 feet is determined to be 125 feet for a 2.0g pullout and using Figure 12 determined to be 310 feet for a 4.0g pullout.

c. Example 3:

Given:

- (1) Bomb - Mk 82
- (2) Mode - unretarded, free fall
- (3) Ejection velocity - 10 fps
- (4) Aircraft speed (release velocity) - 450 knots
- (5) Release (dive) angle - 50 degrees
- (6) Safe-arming time - 6 seconds

Find:

- (1) Minimum release altitude so that the bomb will hit the target and be armed before impact
- (2) Recovery altitude for the aircraft using 2.0g and 4.0g pullout.

Using Figure 96 the release altitude is approximately 4000 feet. The pullout recovery altitude corresponding to this altitude for a 2.0g pullout is non-existent, for the 50-degree release curve does not intersect any 2.0g pullout curve at a time below 6 seconds; therefore, the aircraft will not be able to pullout from this dive. Using Figure 105, again there is no intersection of the 50-degree release curve and the pullout recovery curves below the intersection of the 6-second curve and the 50-degree release curve. It can be seen from Figure 105 that the 200-foot pullout recovery altitude intersects the 50-degree release curve at 4100-foot altitude; therefore, if the bomb is dropped at this altitude or higher and 4.0g pullout initiated immediately on bomb release the aircraft will have a pullout recovery altitude of at least 200 feet and this drop can be made. For a 2.0 g pullout since no minimum pullout curve intersects the 50-degree curve in Figure 96 all that can be said is that the drop will have to be made above 10,000 feet with no indication given as to how far above 10,000 feet.

d. Example 4:

Given:

- (1) Bomb - Mk 81
- (2) Mode - unretarded

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- (3) Ejection velocity - 10 fps
- (4) Release velocity - 200 knots
- (5) Release angle - 30 degrees
- (6) Safe arming time of fuze - 5 seconds

Find:

- (1) Minimum release altitude so that the bomb will hit the target and be armed before impact
- (2) The recovery altitude of the aircraft corresponding to the minimum release altitude using 2.0g and 4.0g pullout
- (3) The maximum altitude at which the bomb can be dropped and hit the target and the pilot see the target at release if the line of sight to target is limited by a lead angle of 16 degrees

Using Figure 73 to locate the intersection of the 5-second time of fall curve and the 30-degree release curve, the minimum altitude at which the bomb can be dropped, hit the target, and arm is determined to be 1250 feet. The recovery altitude using 2.0g pullout is below 200 feet so this may be an unsafe drop. Using Figure 82 the recovery altitude for 4.0g pullout is approximately 650 feet. Using either Figure 73 or Figure 82 the intersection of the 16-degree sight curve, which is indicated by long and short dashes, and the 30-degree release angle curve is located at 2050-foot altitude. For release altitudes greater than 2050 feet the pilot would not be able to see the target at the time of release. Assume the dive had been made at 60 degrees, the 16-degree sight limit curve and the 60-degree release curve do not intersect; therefore, at any point on the 60-degree release curve up to an altitude of 10,000 feet the pilot can see the target.

REMARKS

10. The release curves presented in this report are based on a mathematical model which was programmed for the IBM 7090 computer. The mathematical model presented here is similar to one used at the Naval Weapons Laboratory (NWL), Dahlgren, Va. The program uses data processed by the NWL from drop tests conducted at the Naval Ordnance Test Station, China Lake, California.

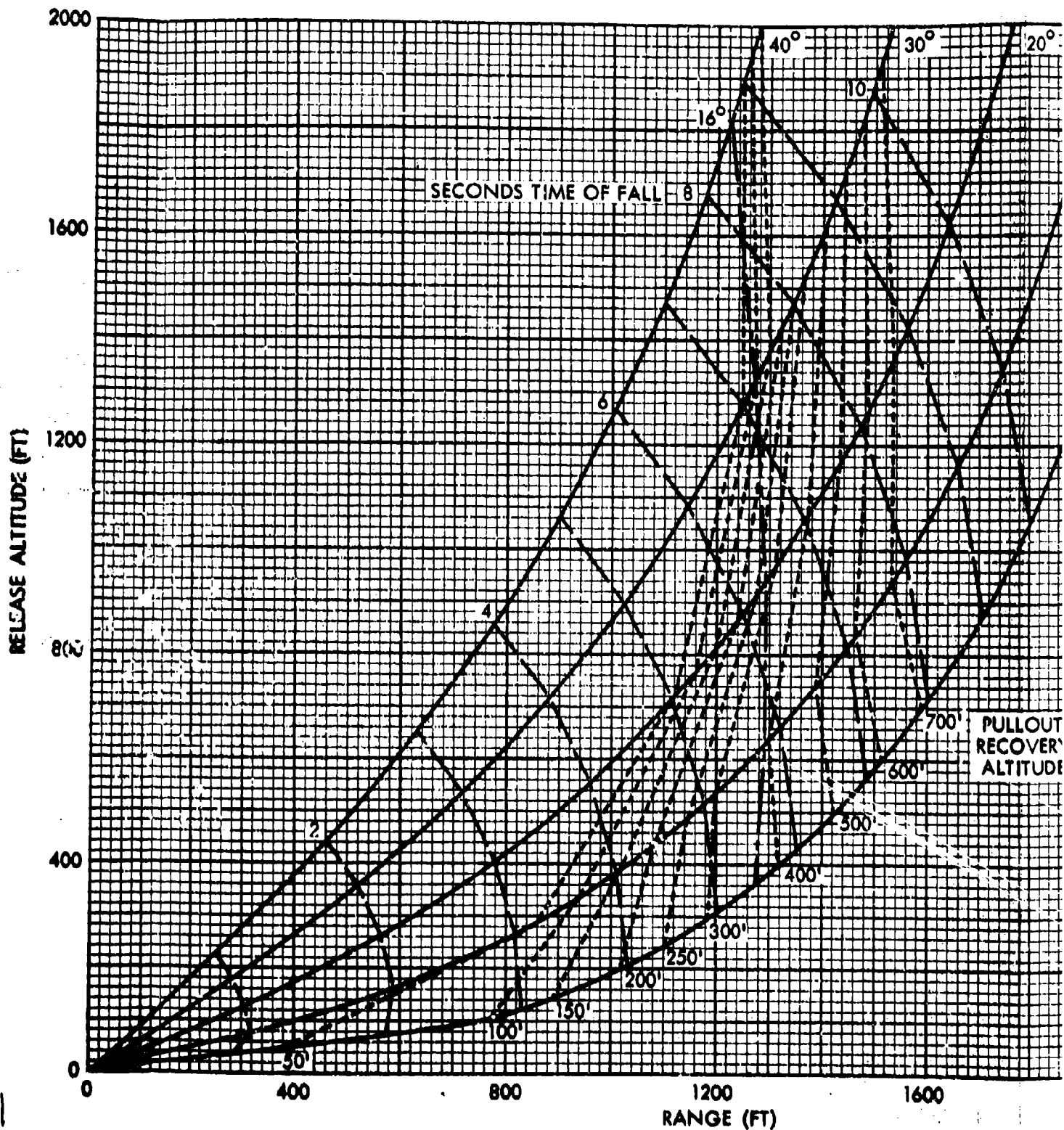
11. The curves presented here are not intended to replace the ballistic tables but rather to present them in a more usable

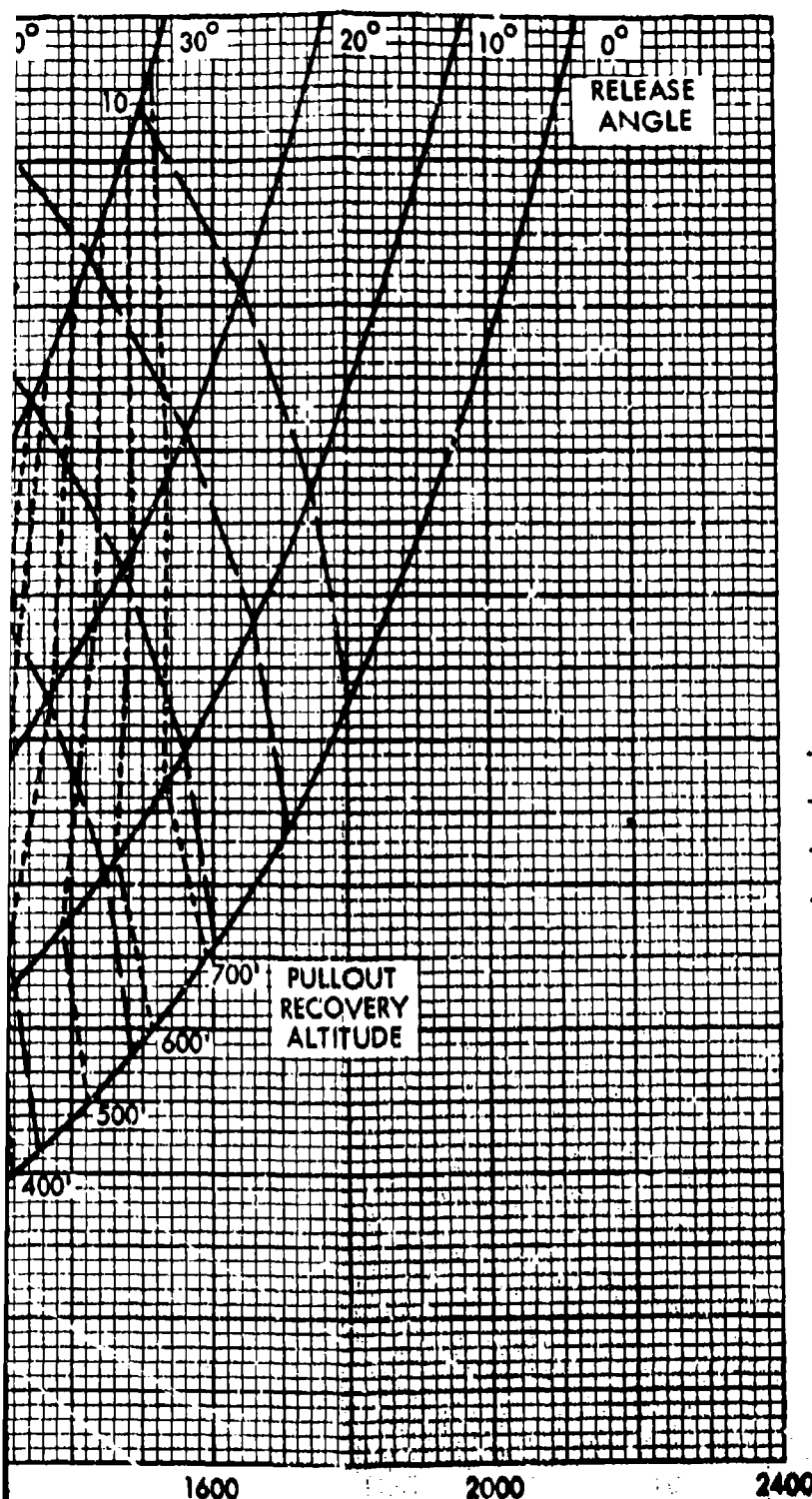
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form. Changes in drag of the weapon, pilot reaction time and aircraft pullout characteristics are the major areas where inaccuracies could be introduced, but unless there are radical changes, the curves will still be usable.

TABLE 1
RANGE CORRECTION TABLE
(50-FOOT ALTITUDE, 0-DEGREE RELEASE ANGLE, RETARDED MODE)

Release Velocity (knots)	Mk 81 Range Ejection Velocity		Mk 82 Range Ejection Velocity	
	0 fps (feet)	10 fps (feet)	0 fps (feet)	10 fps (feet)
200	568	480	574	486
250	700	591	710	602
300	827	700	892	716
350	949	805	969	826
400	1064	900	1091	933
450	1173	1003	1206	1034
500	1273	1095	1316	1134
550	1365	1182	1445	1255
600	1450	1266	1512	1316



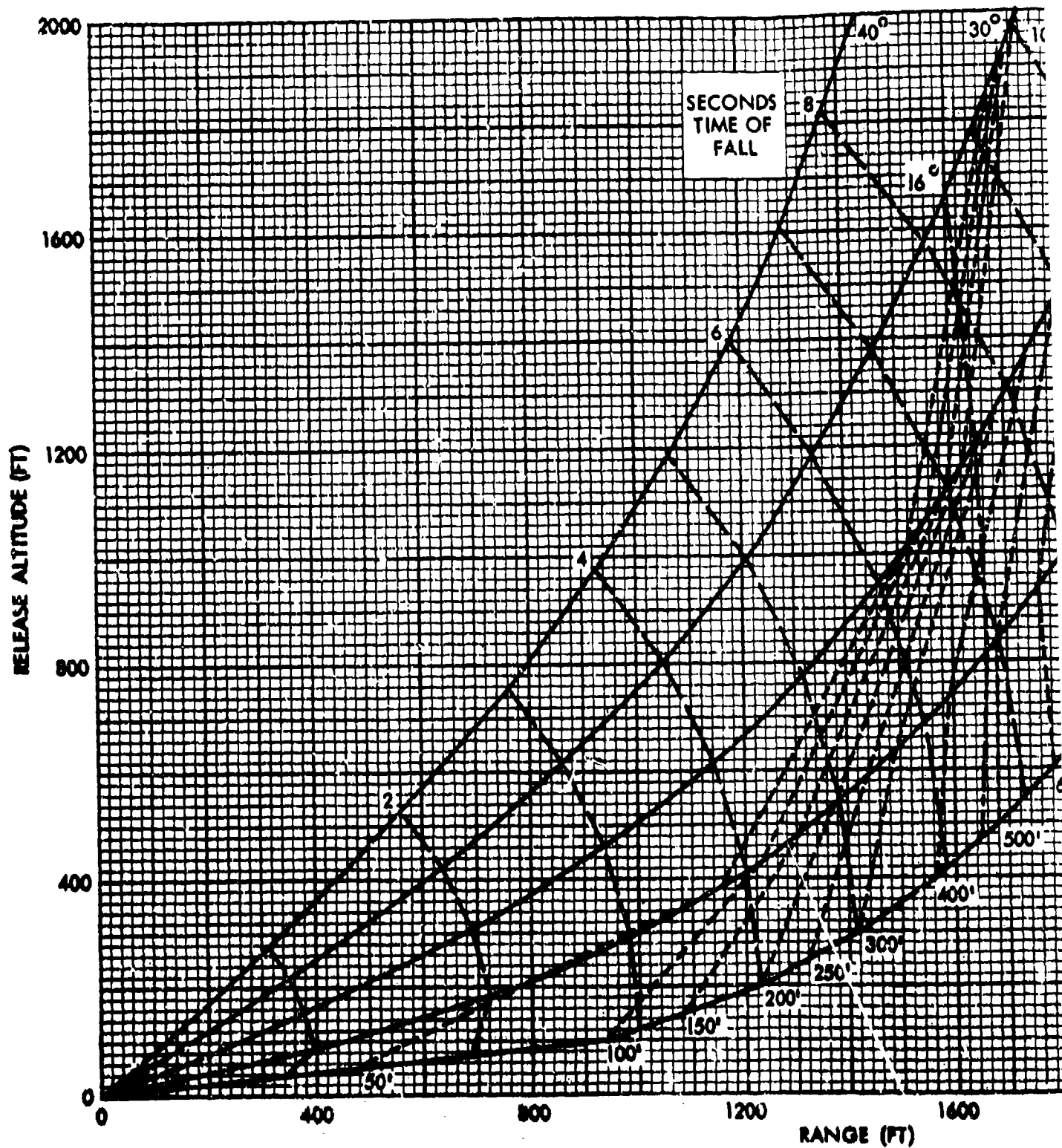


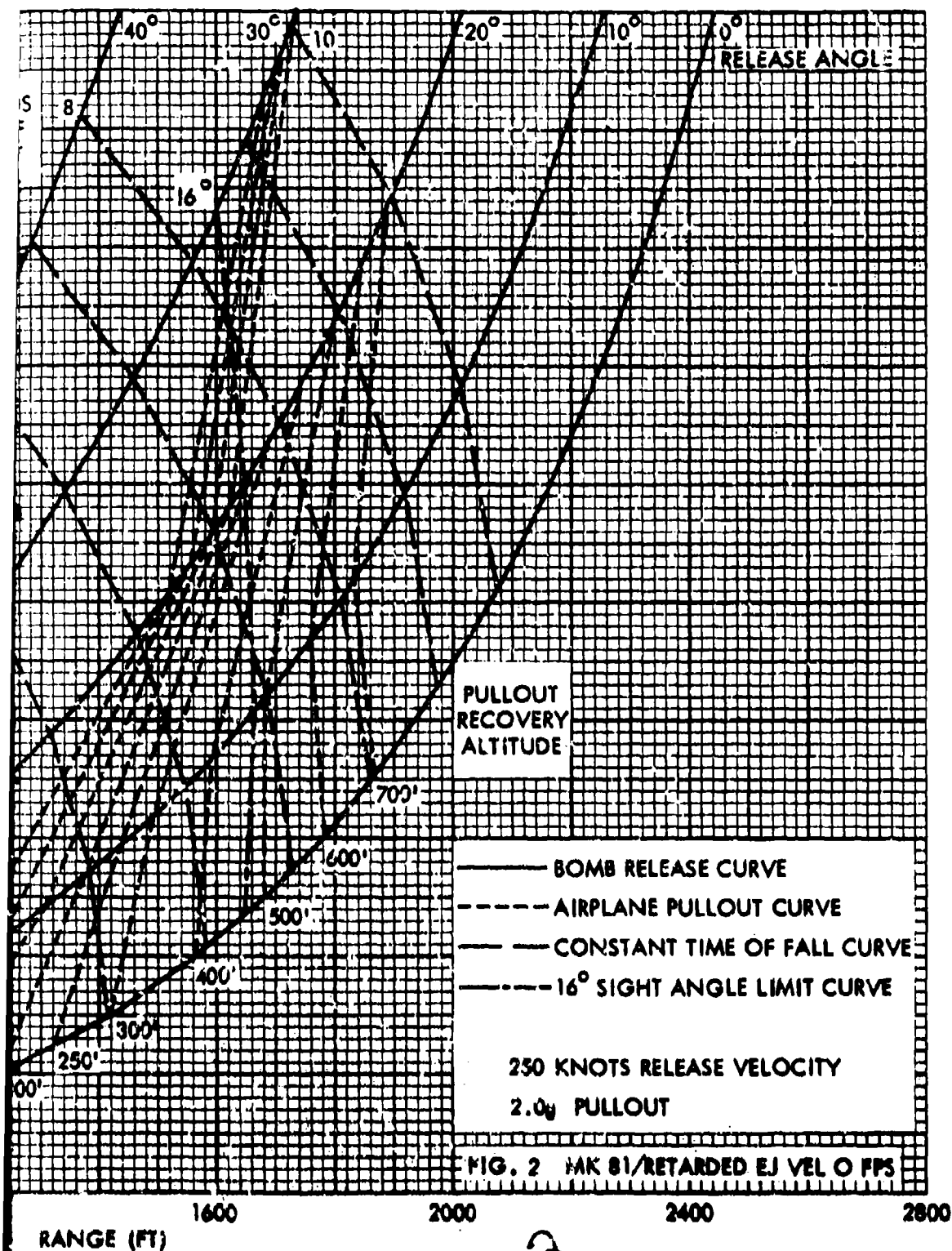
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- AIRPLANE PULLOUT CURVE
- . - . - . CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

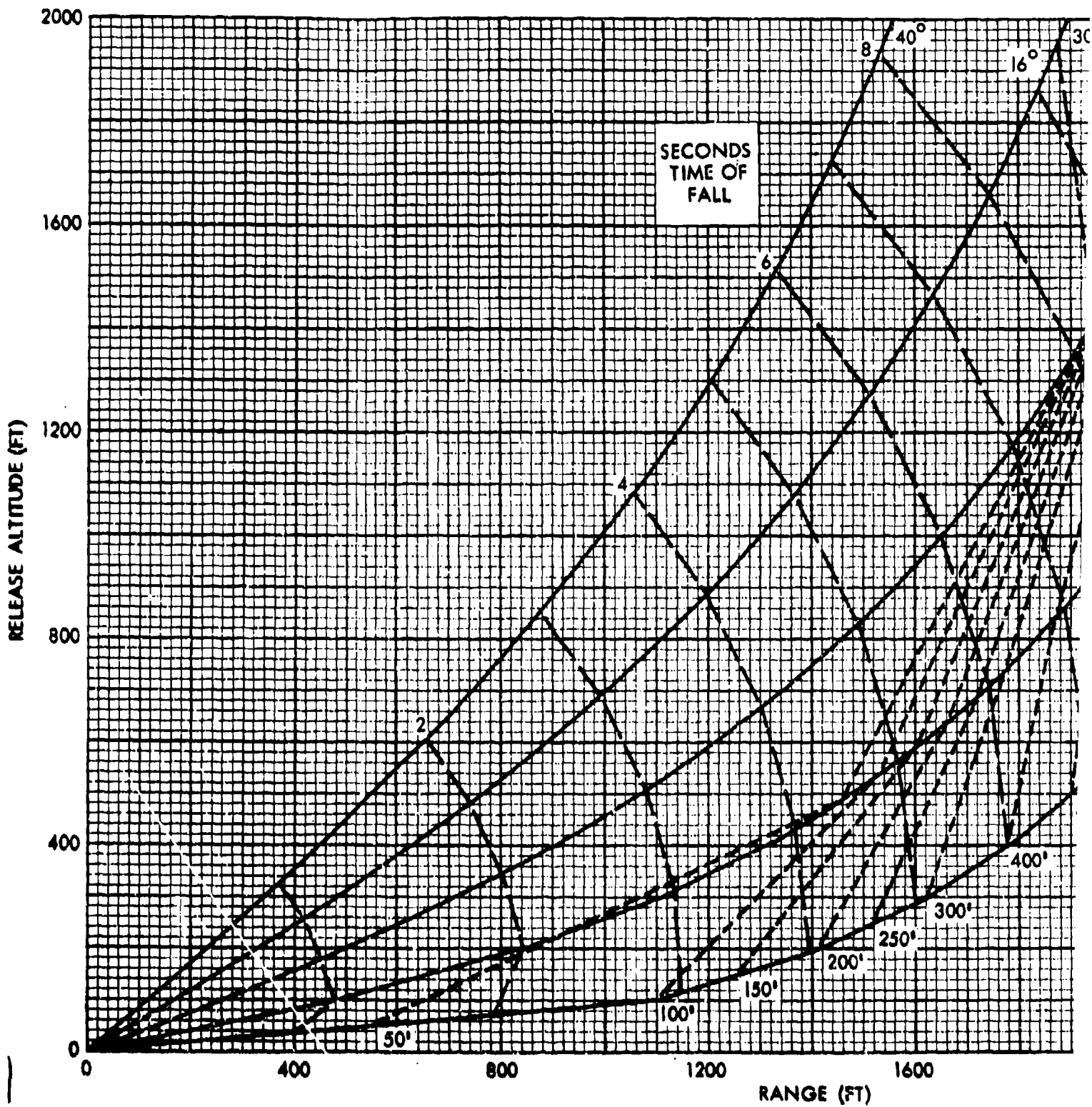
200 KNOTS RELEASE VELOCITY

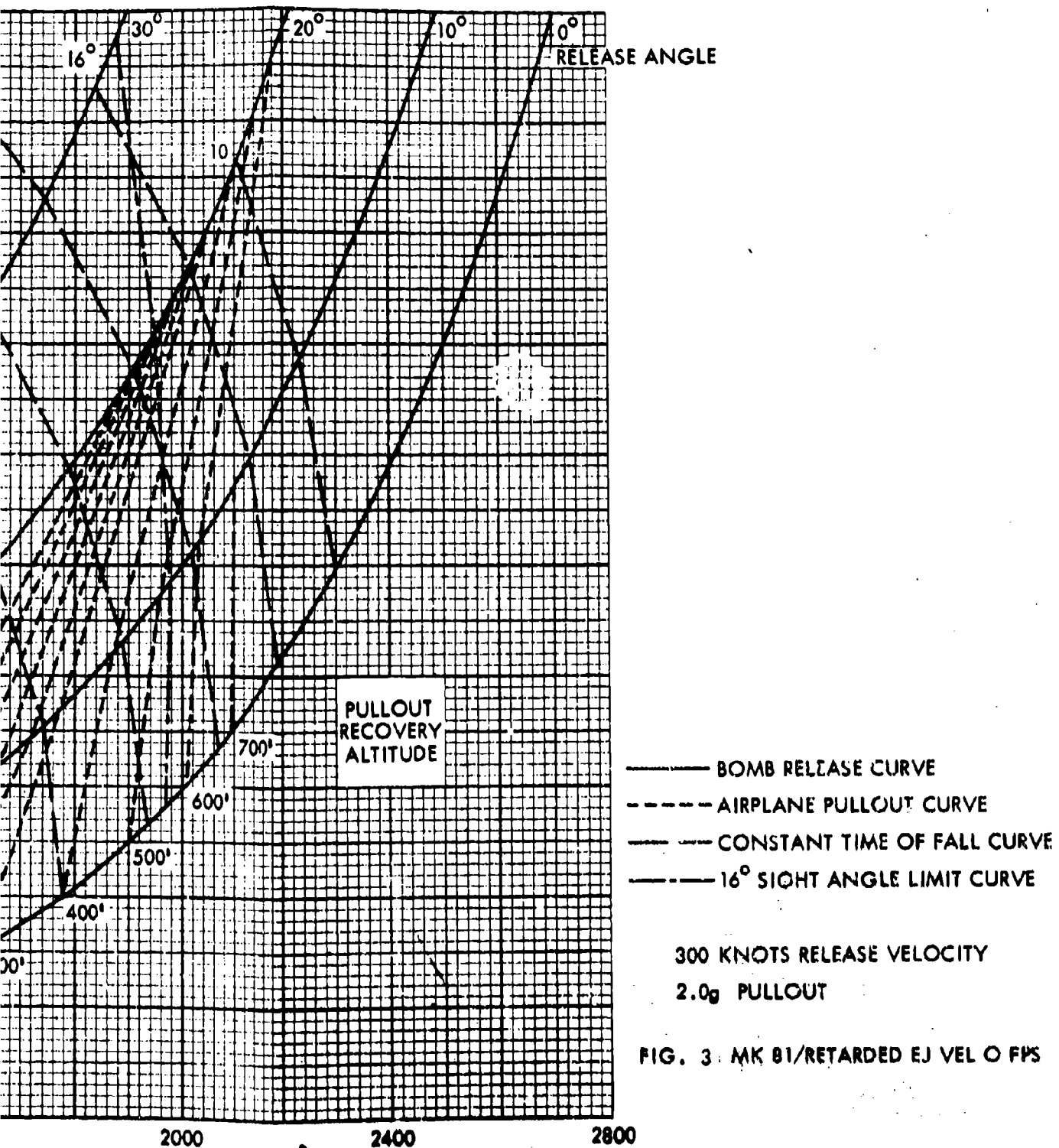
2.0g PULLOUT

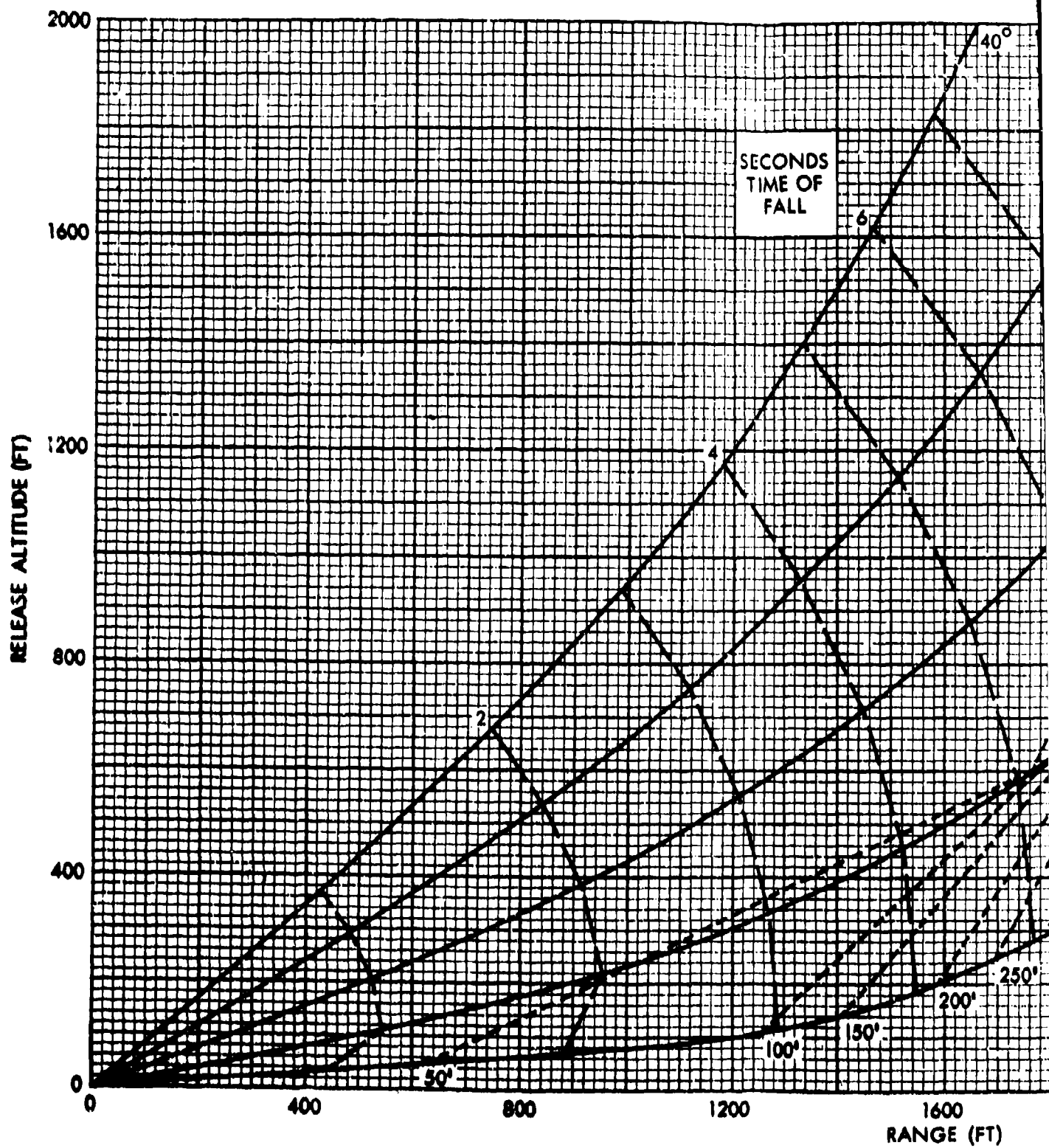
FIG. 1 MK 81/RETARDED EJ VEL O FPS

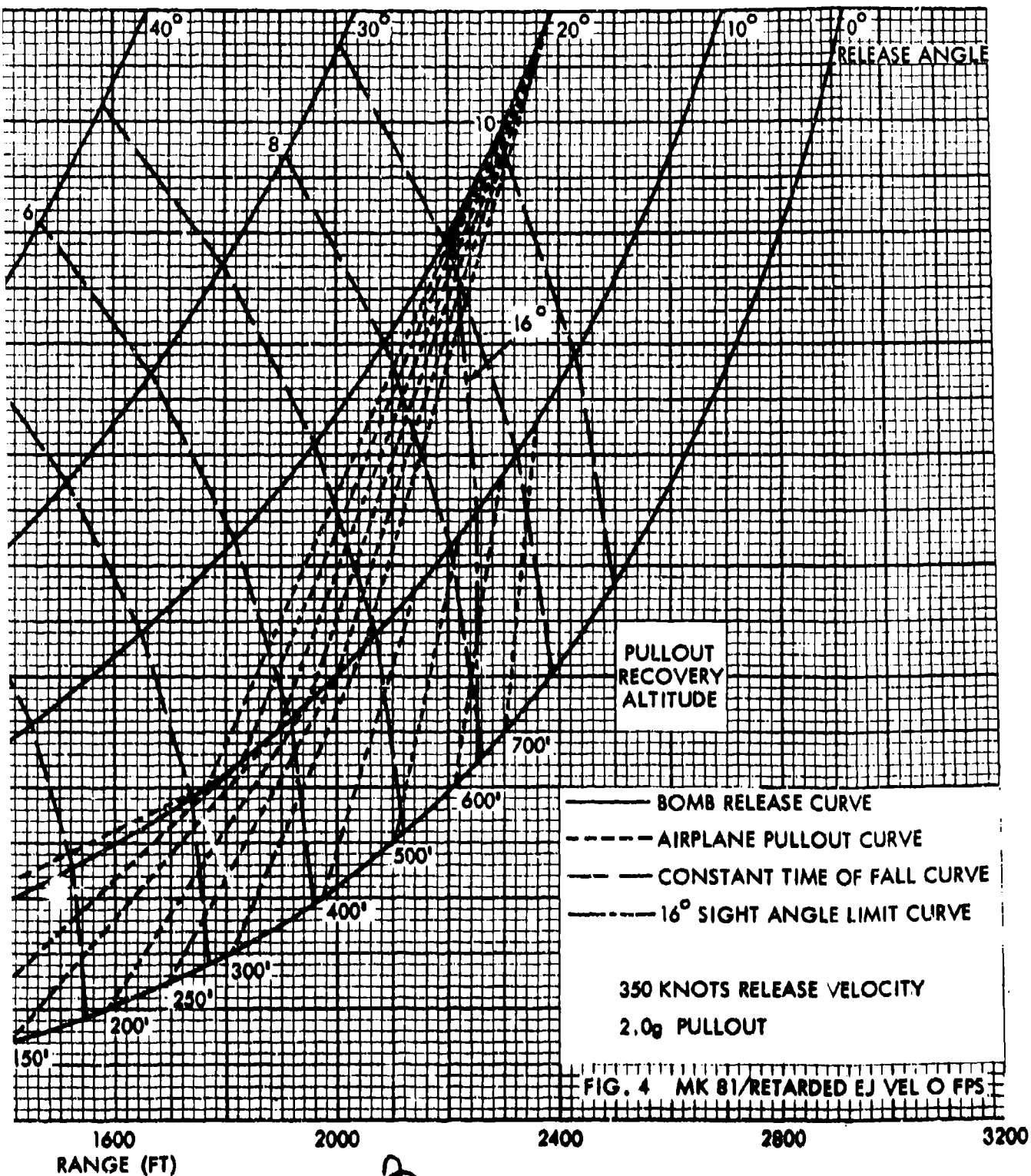


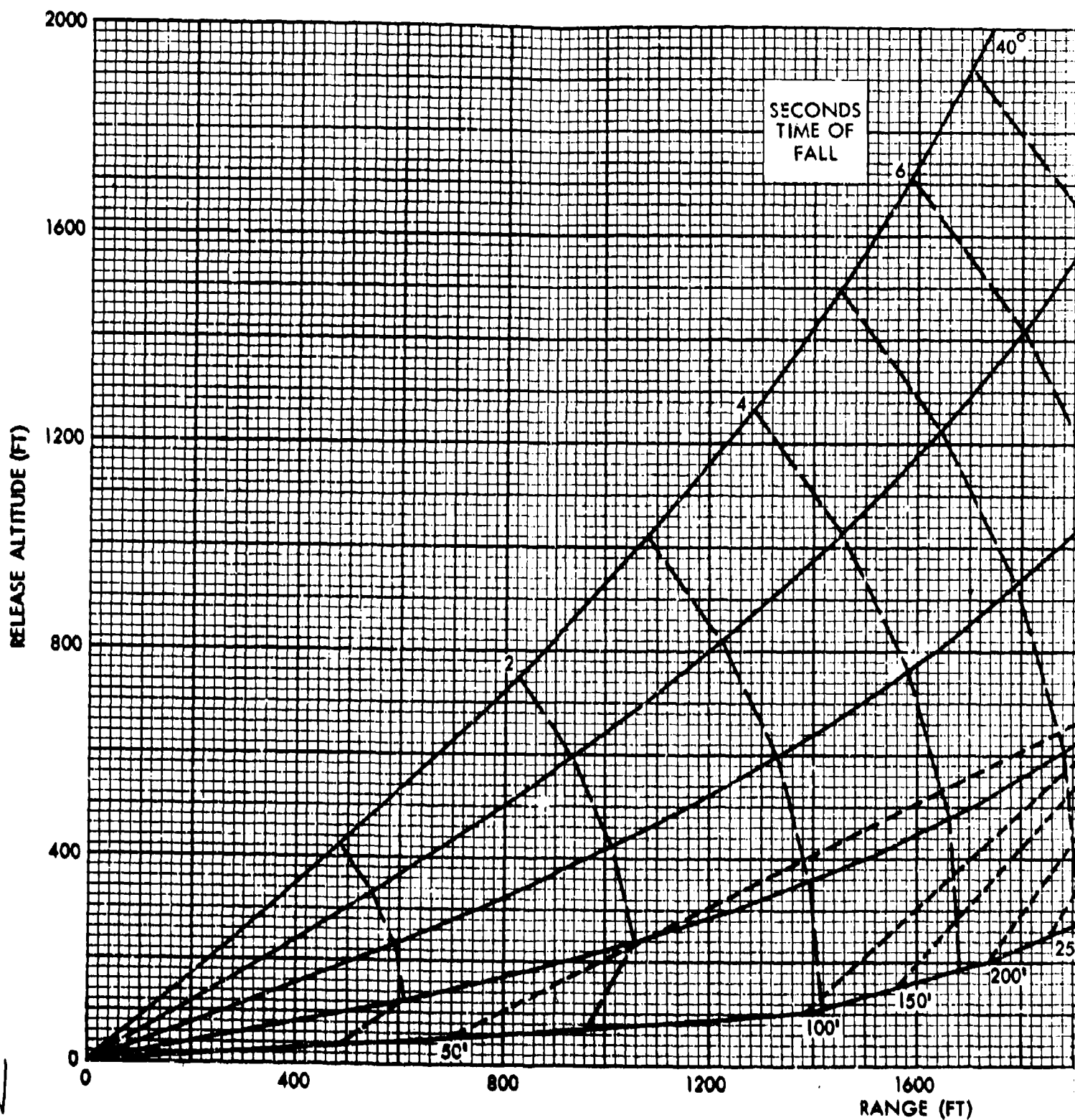












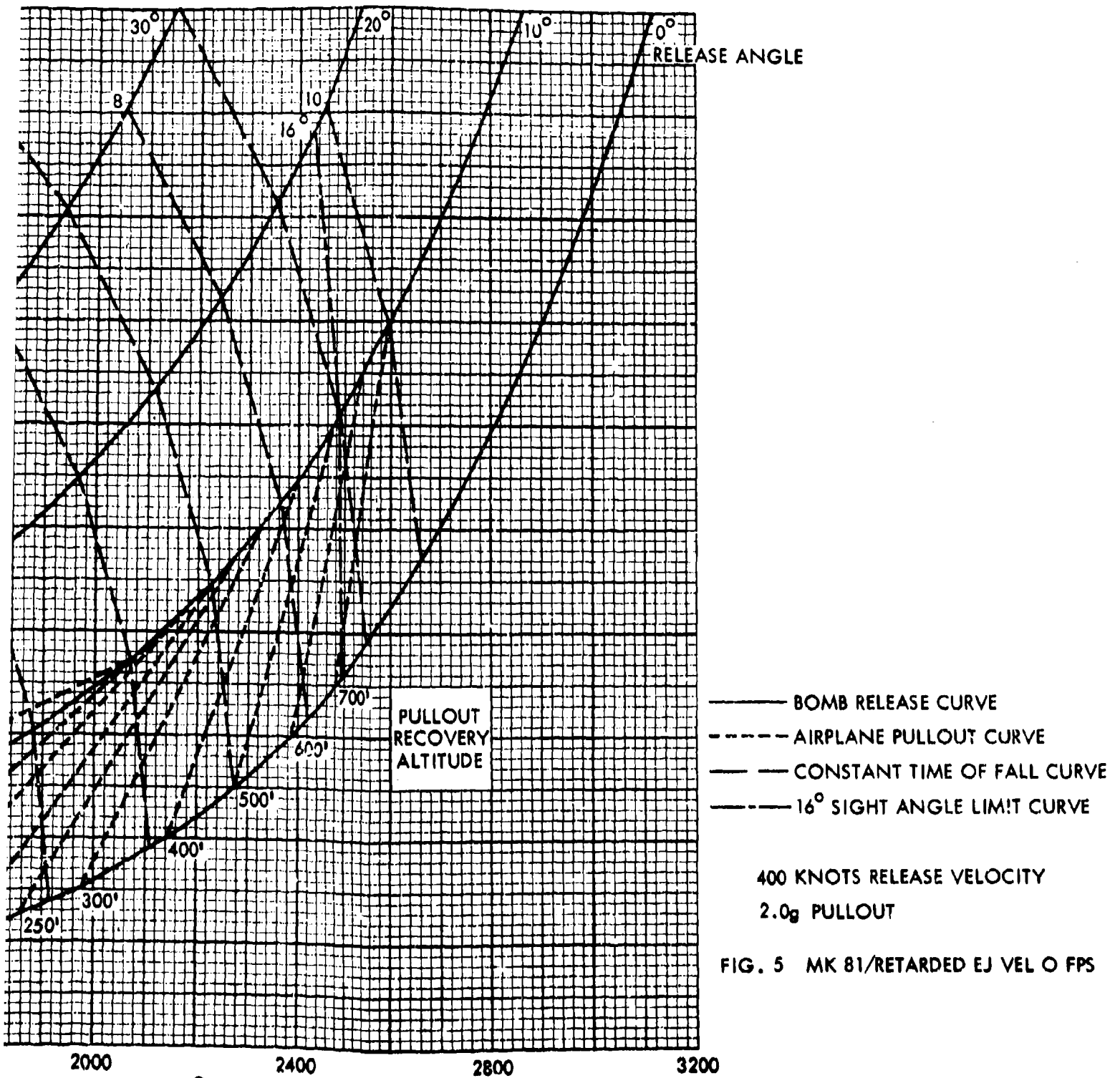
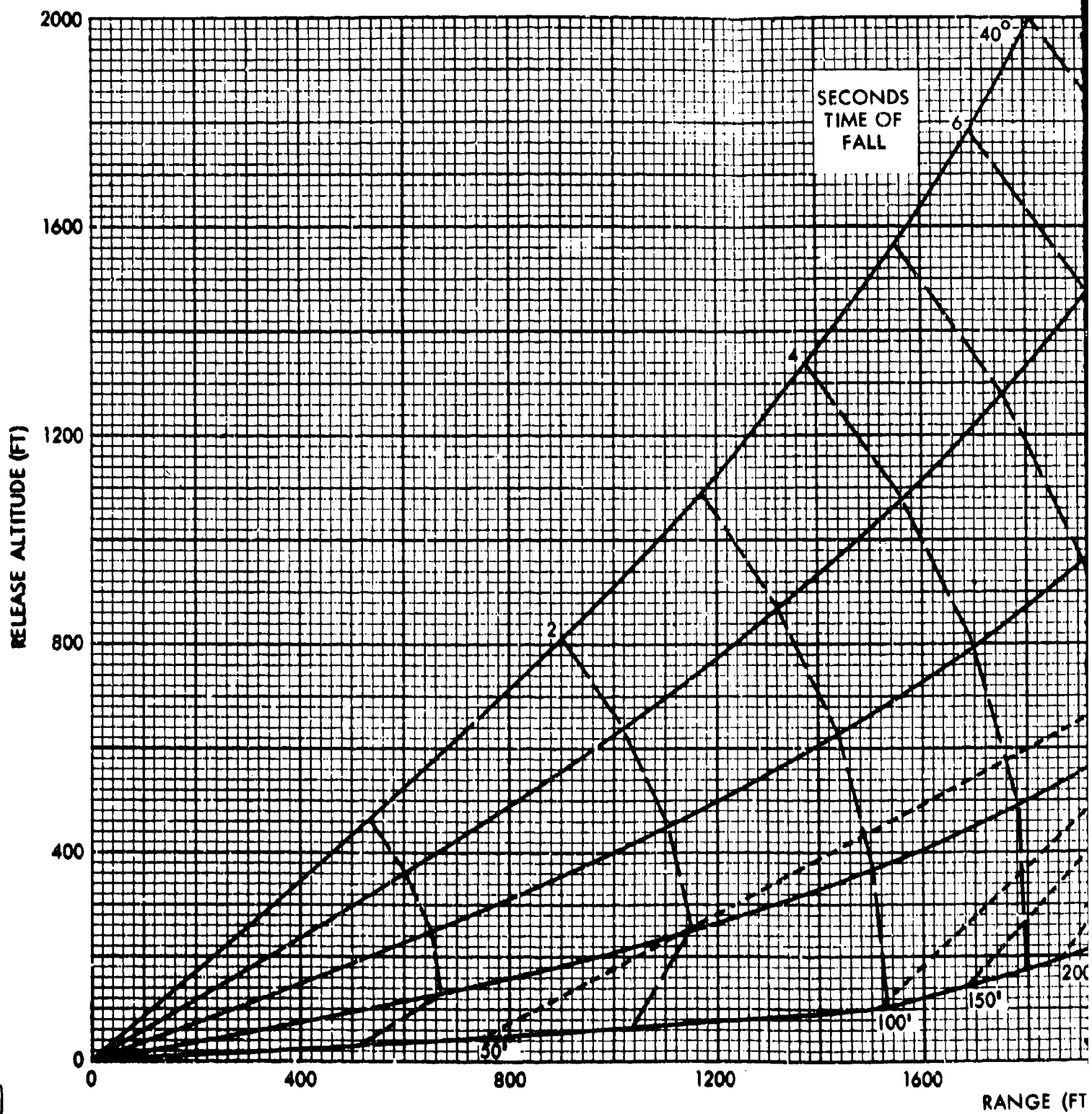
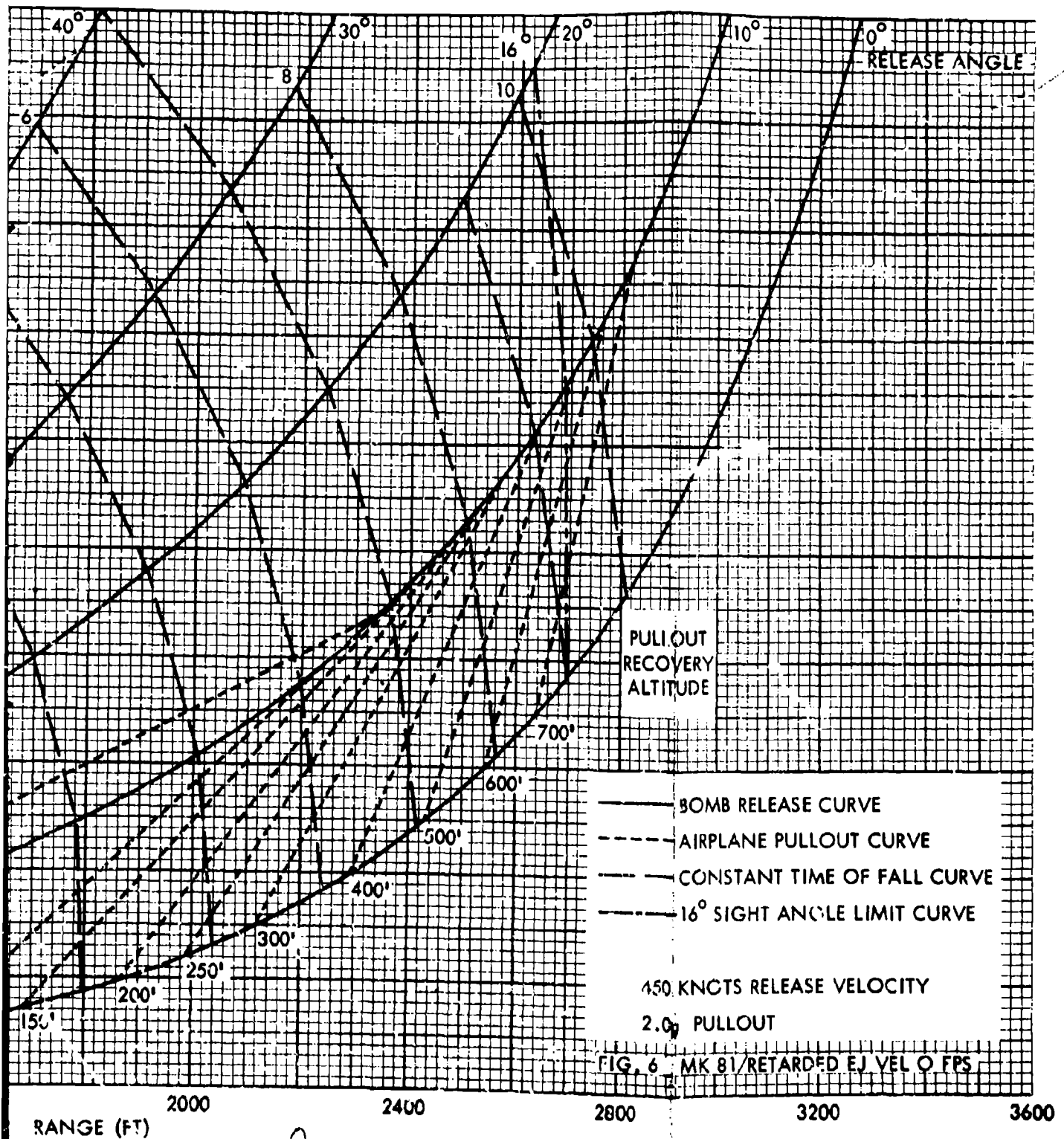
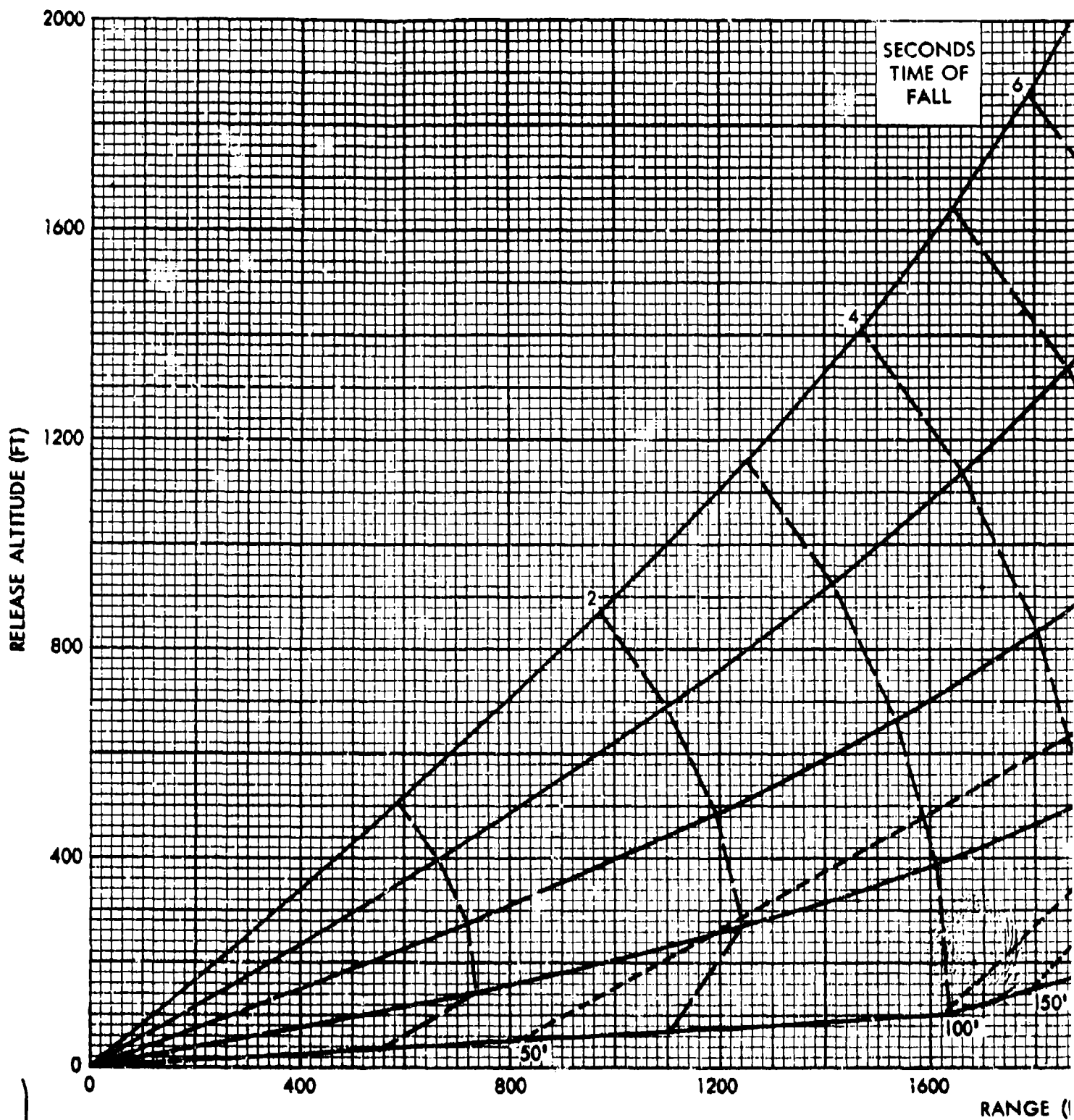


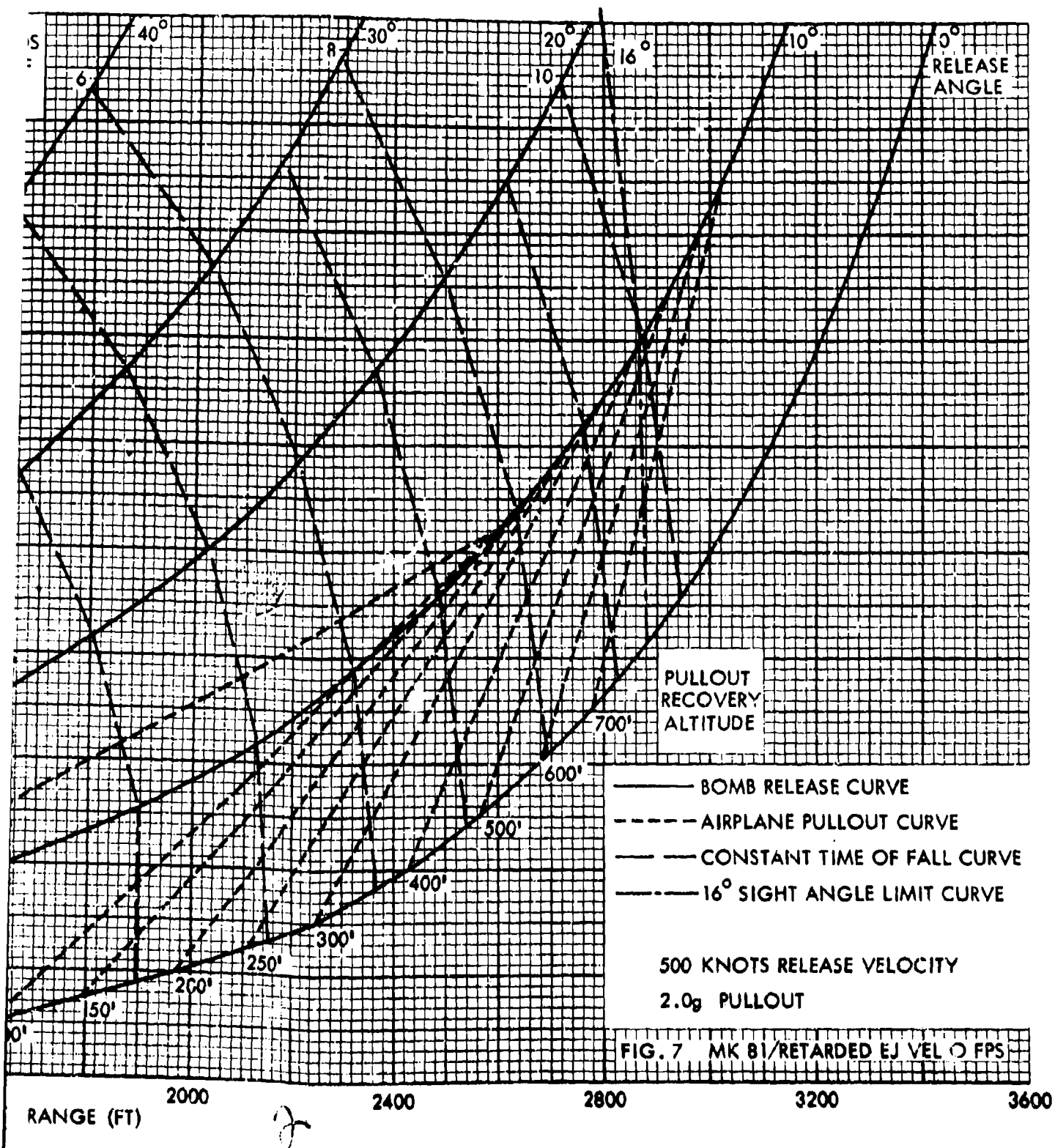
FIG. 5 MK 81/RETARDED EJ VEL 0 FPS

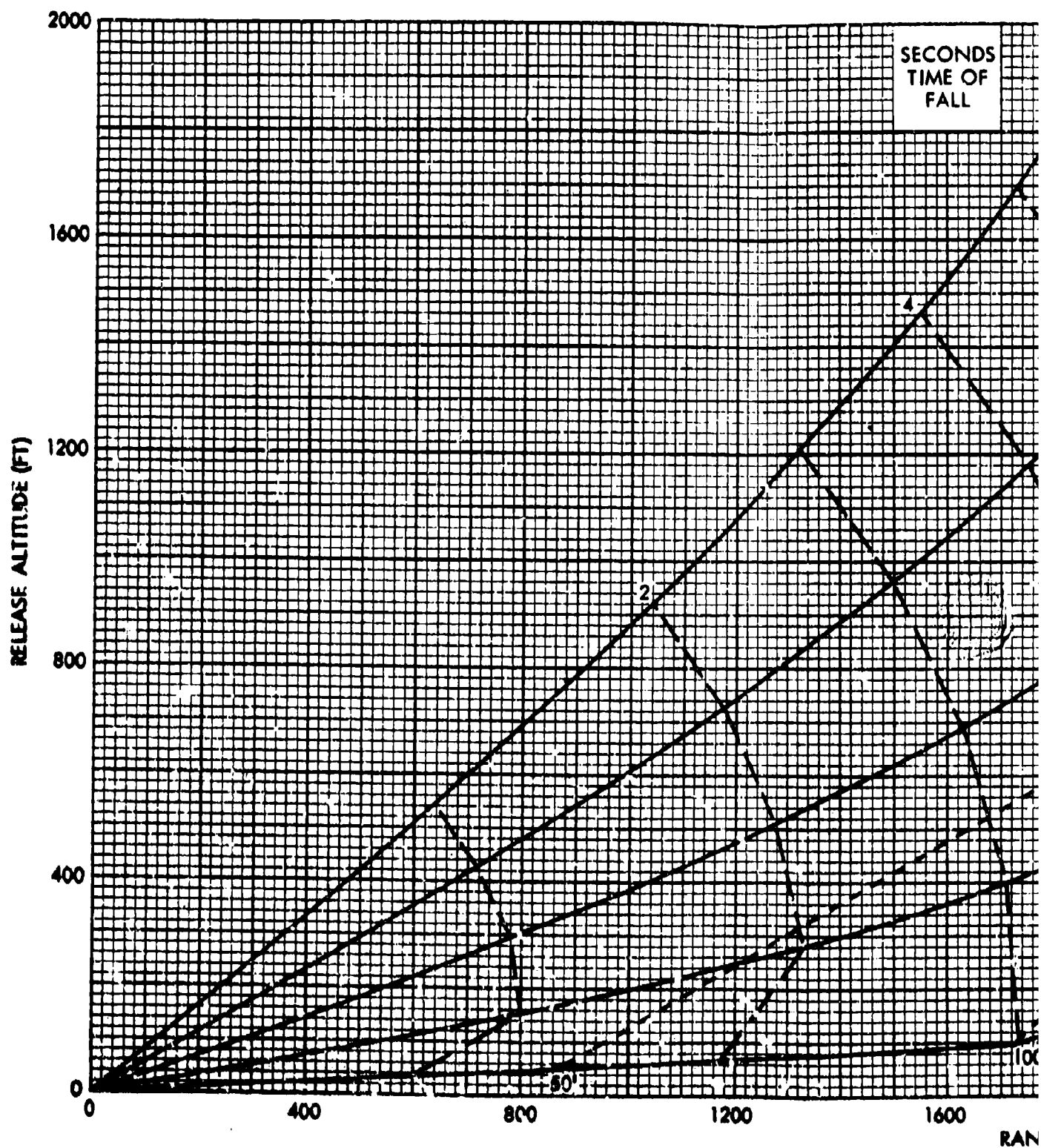


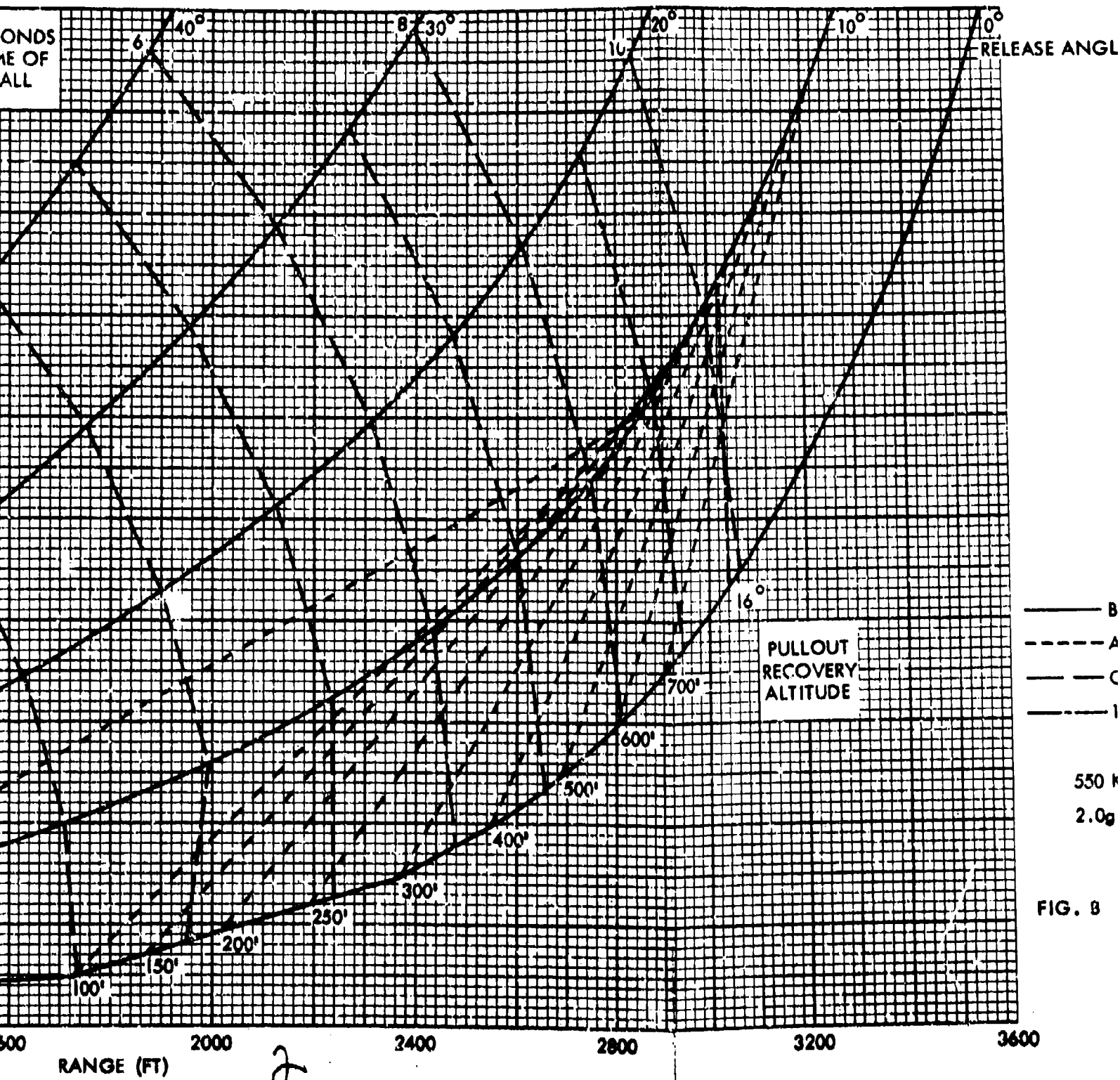




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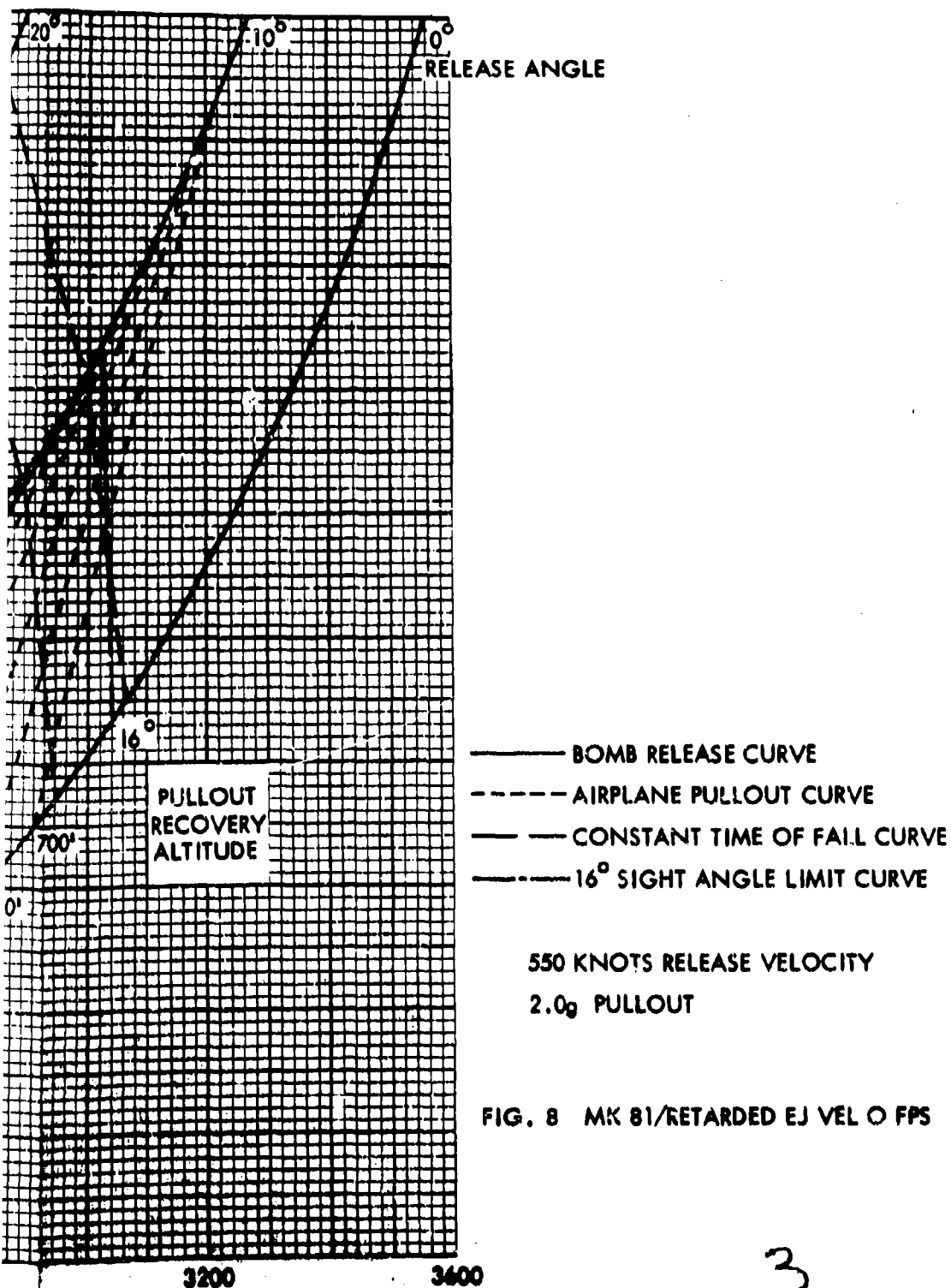
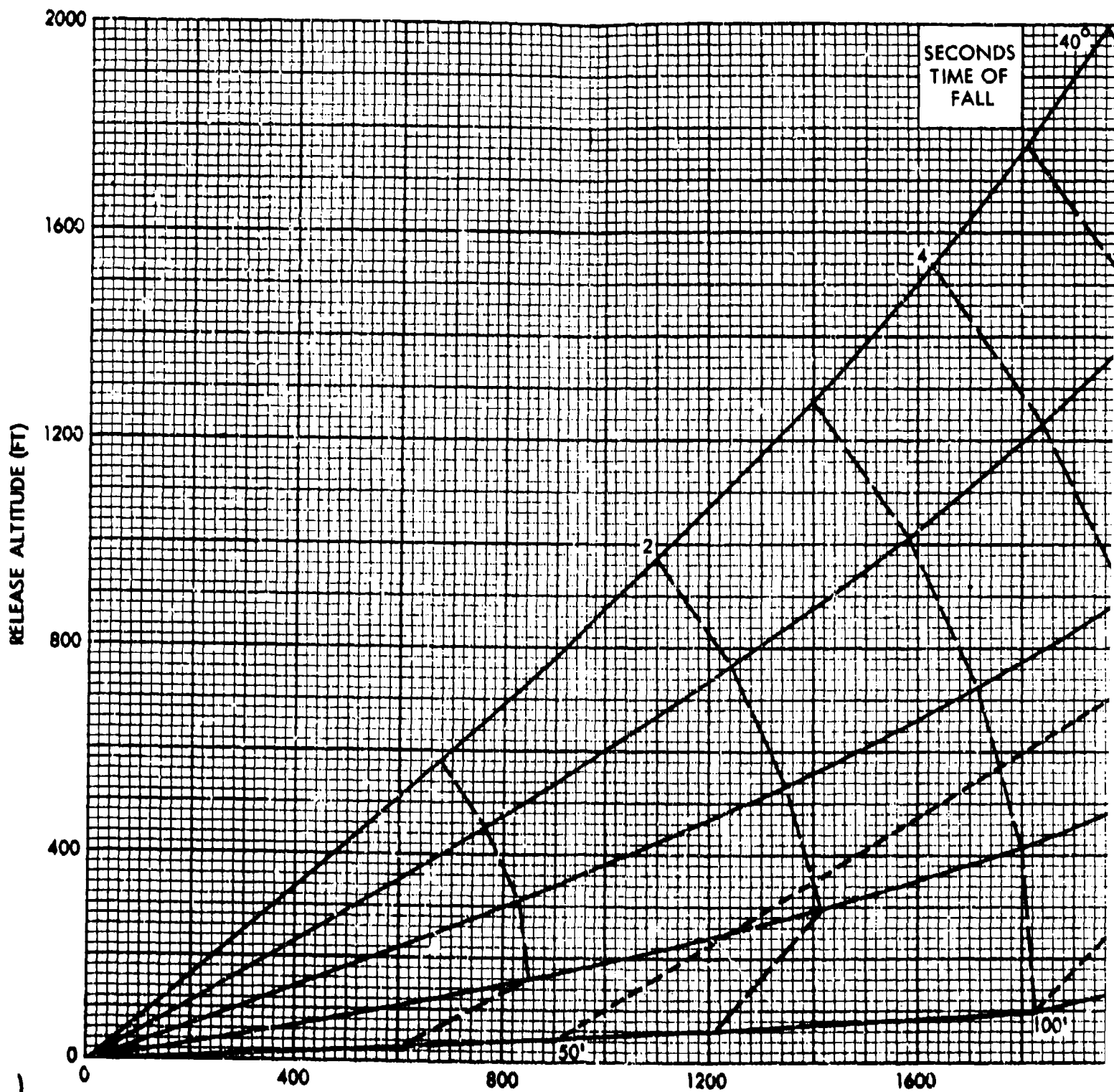
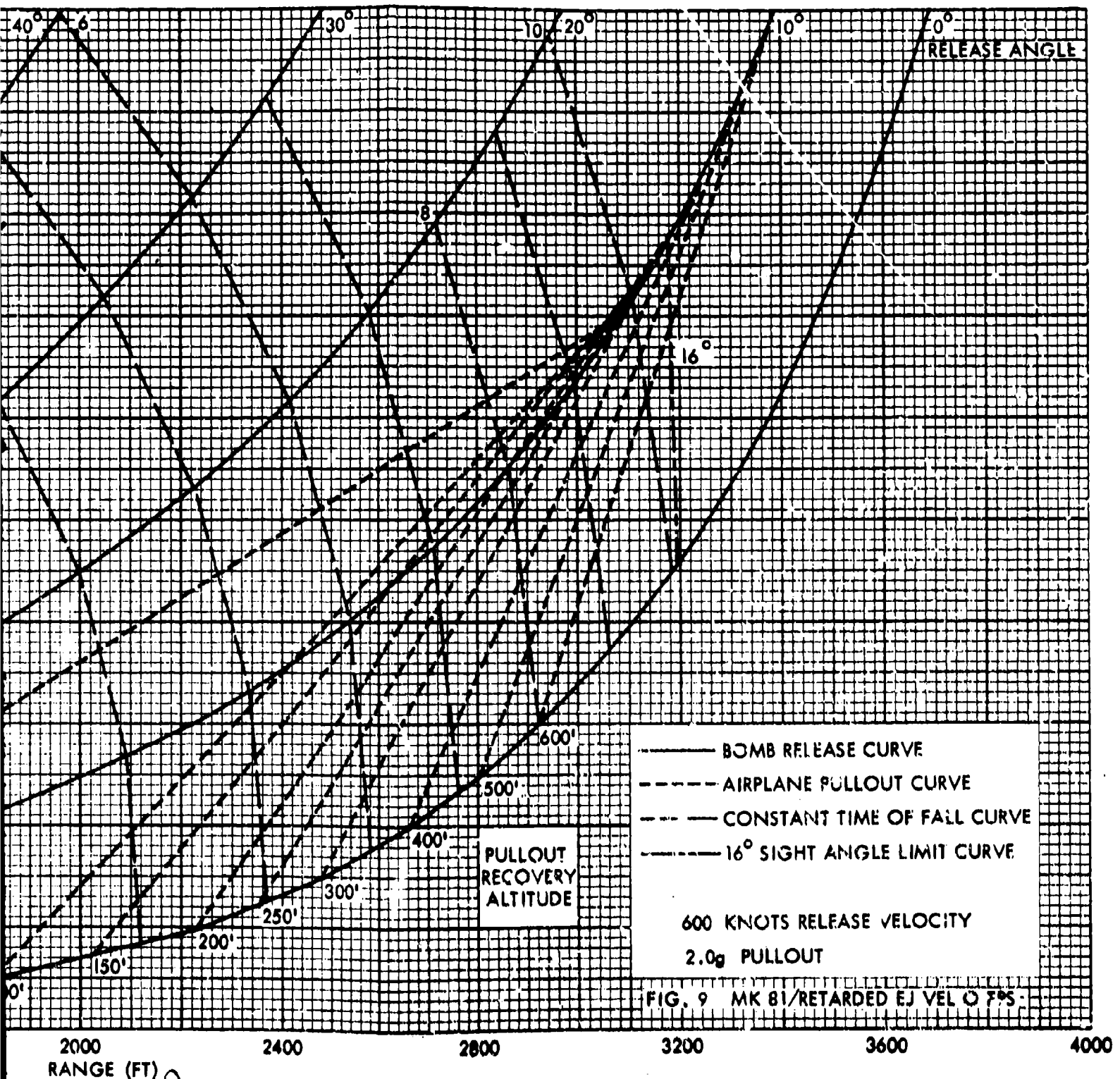
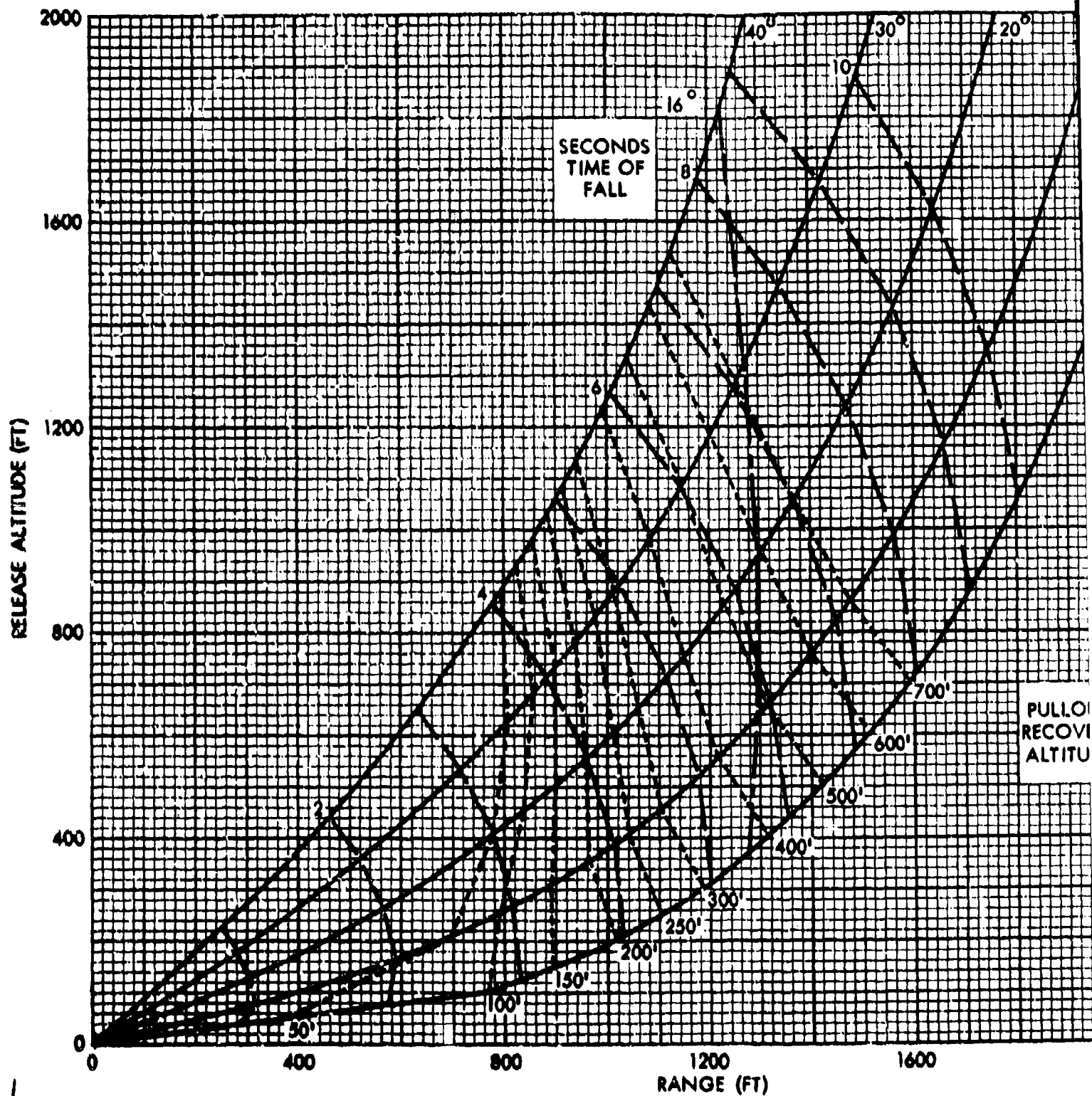


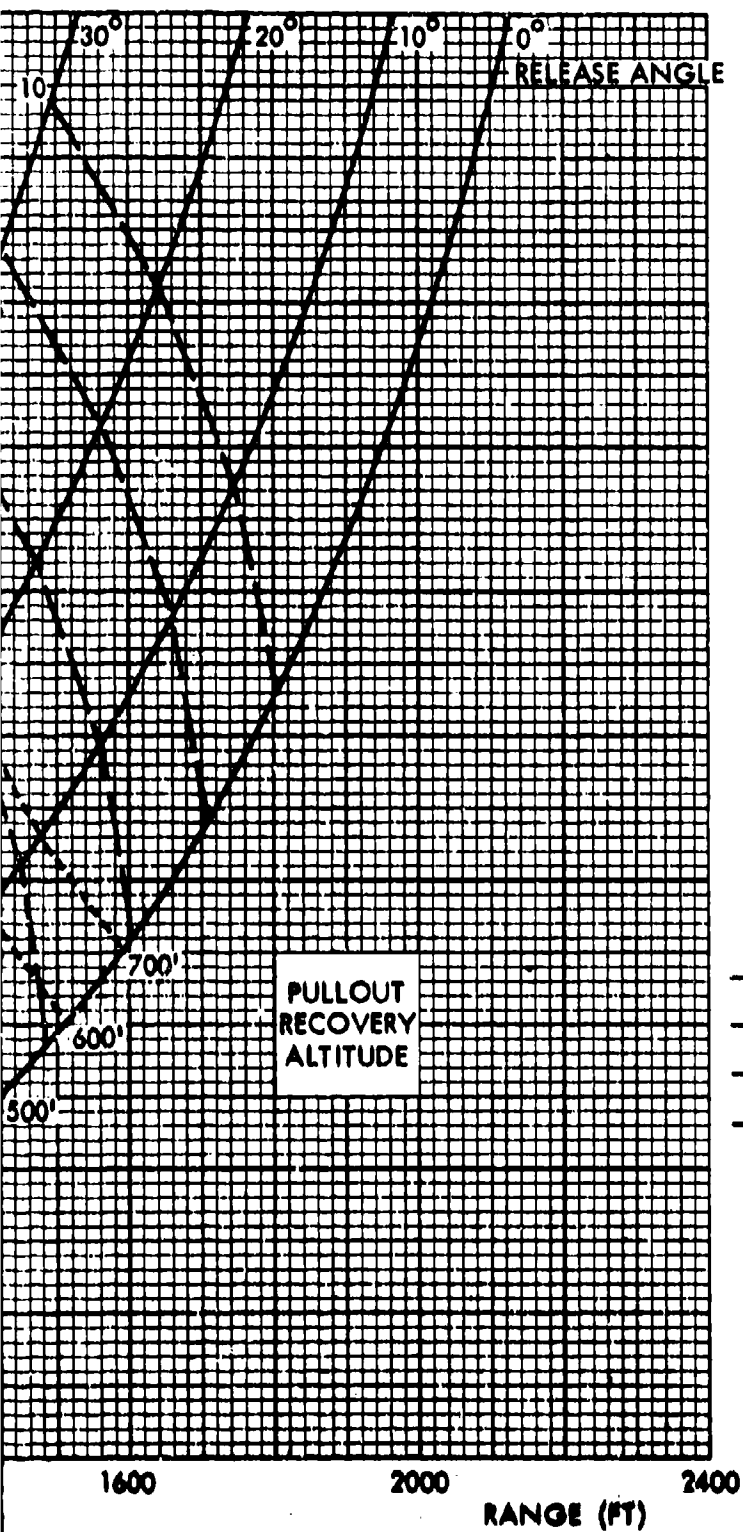
FIG. 8 MK 81/RETARDED EJ VEL 0 FPS







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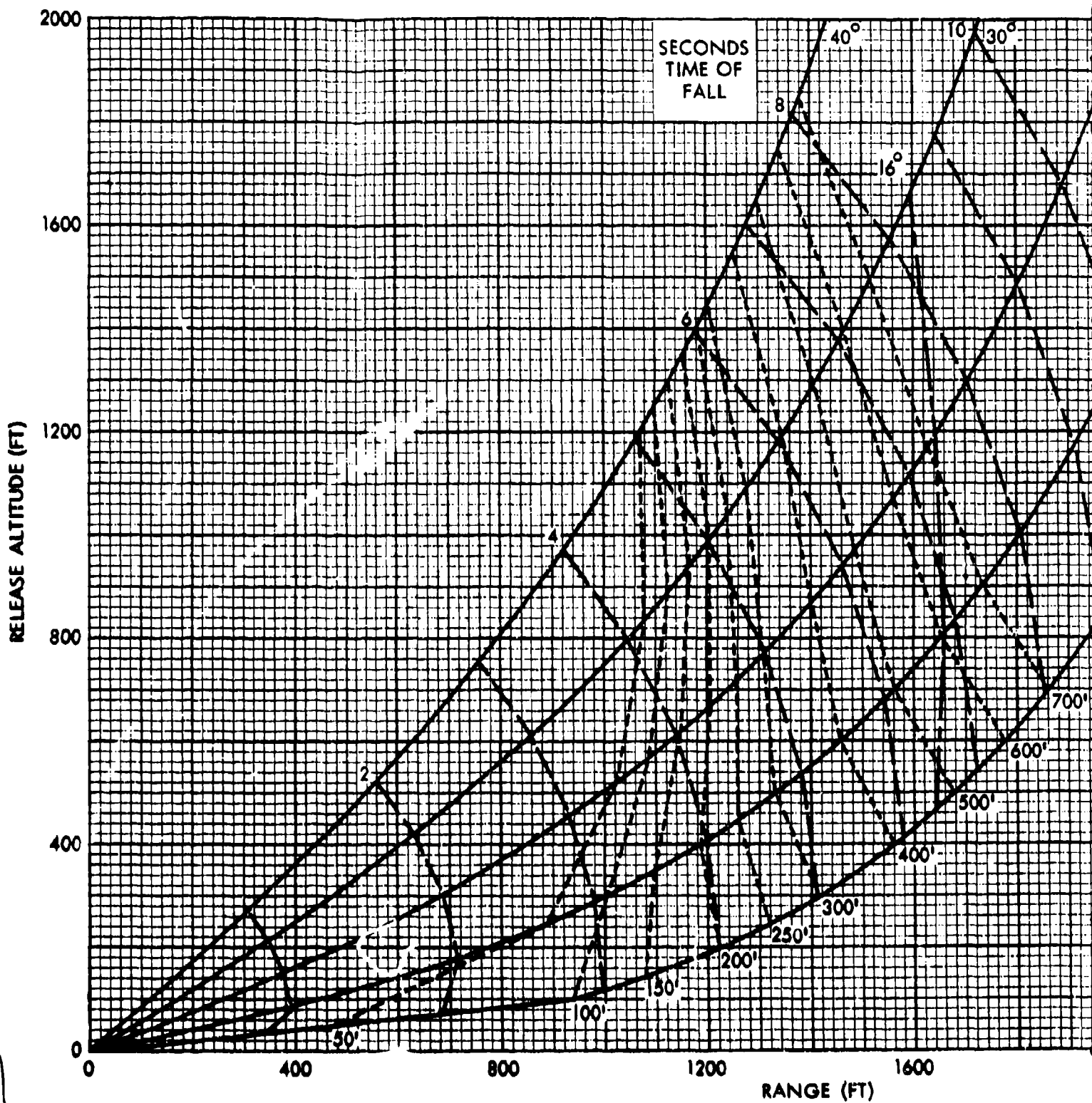


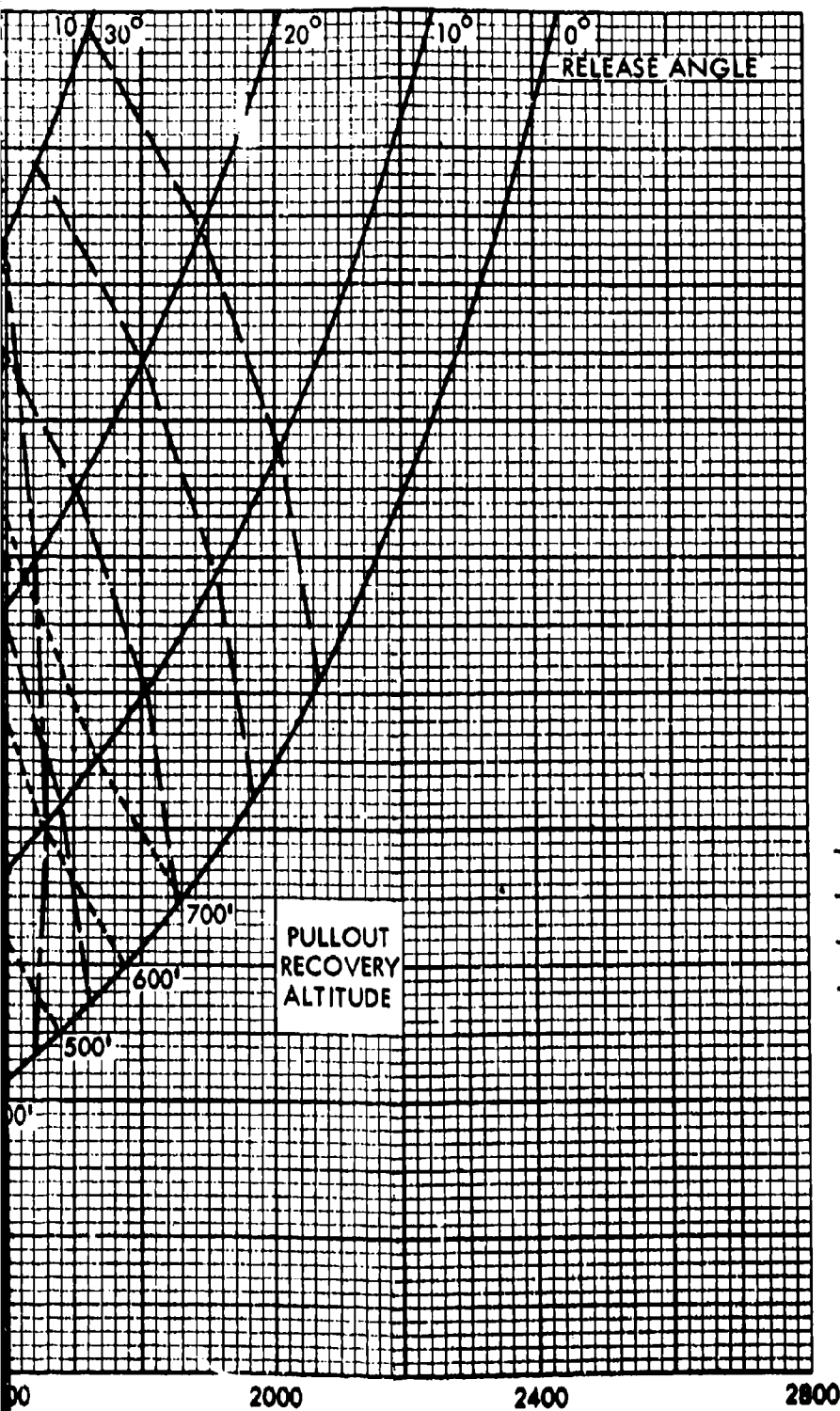
- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG. 10 MK 81/RETARDED EJ VEL 0 FPS



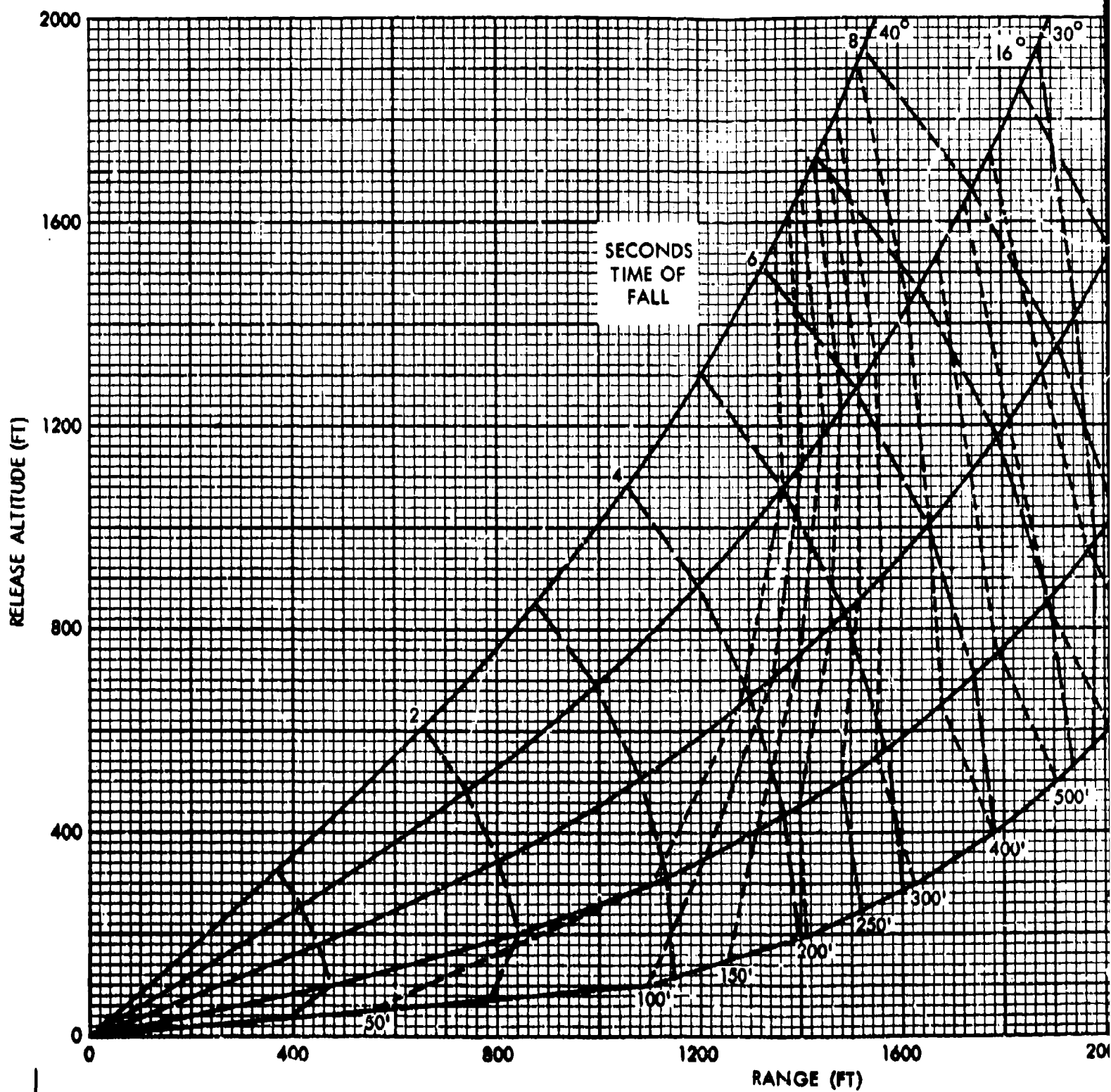


- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG.11 MK 81/RETARDED EJ VEL O FPS



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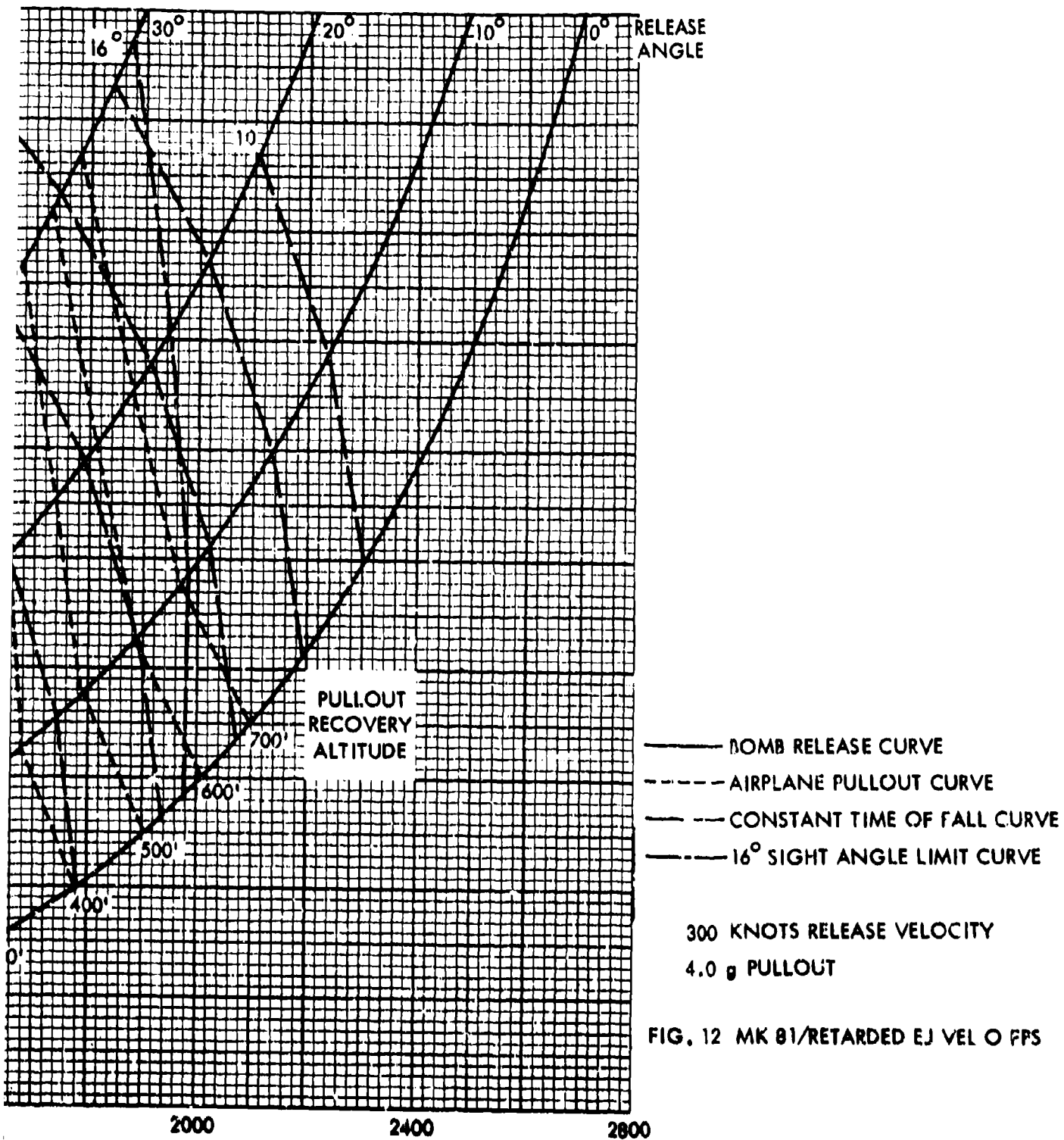
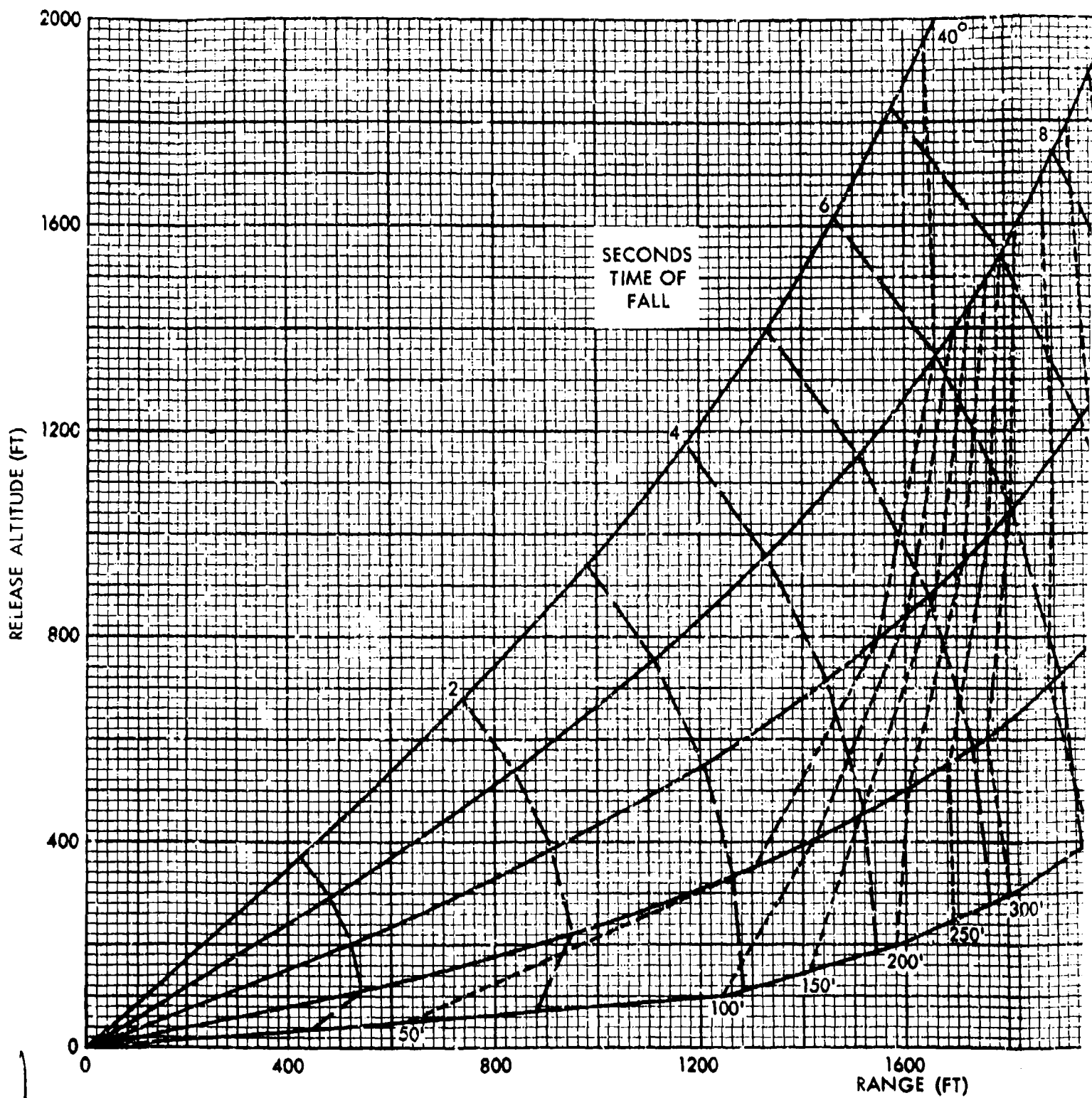
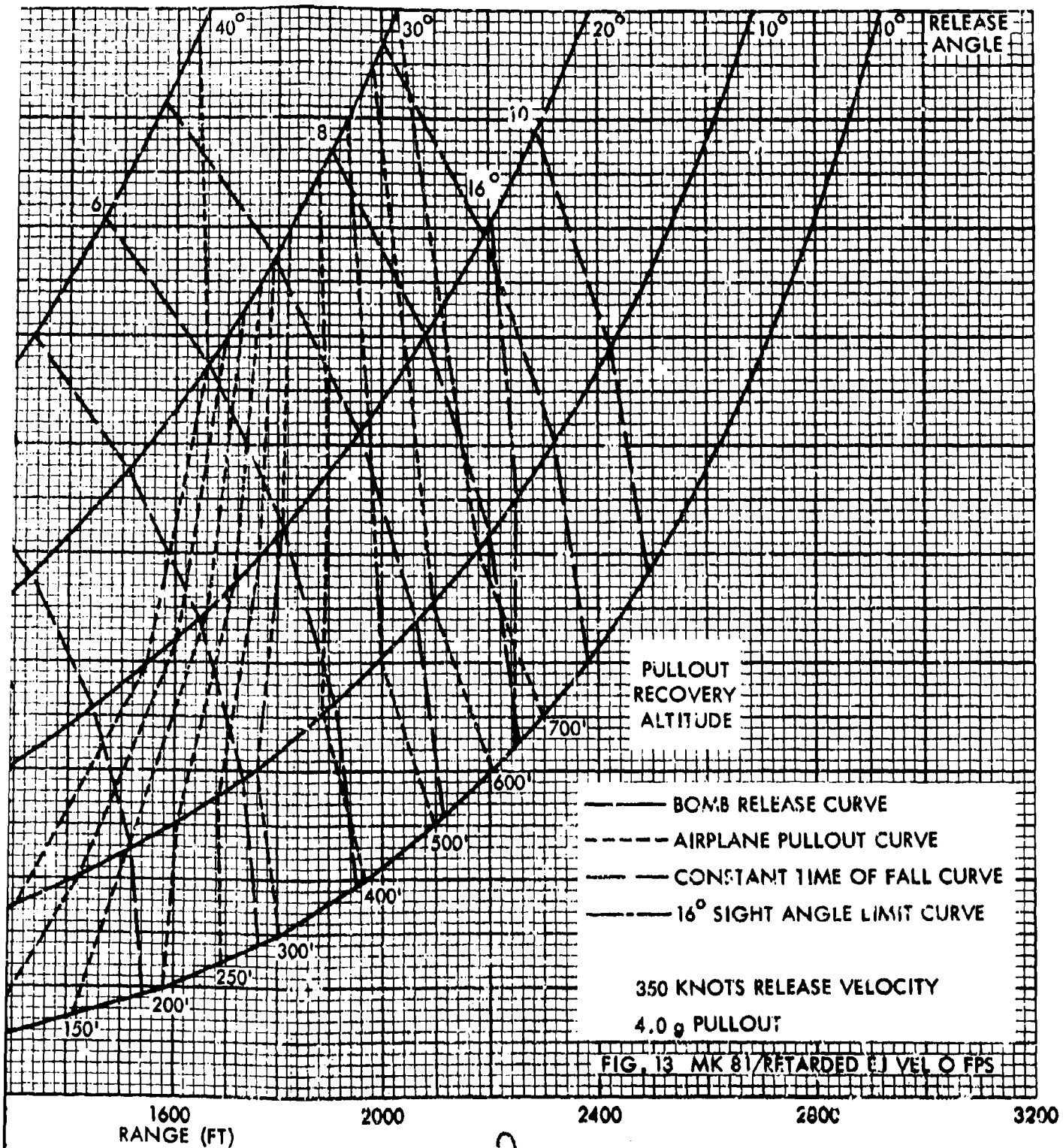
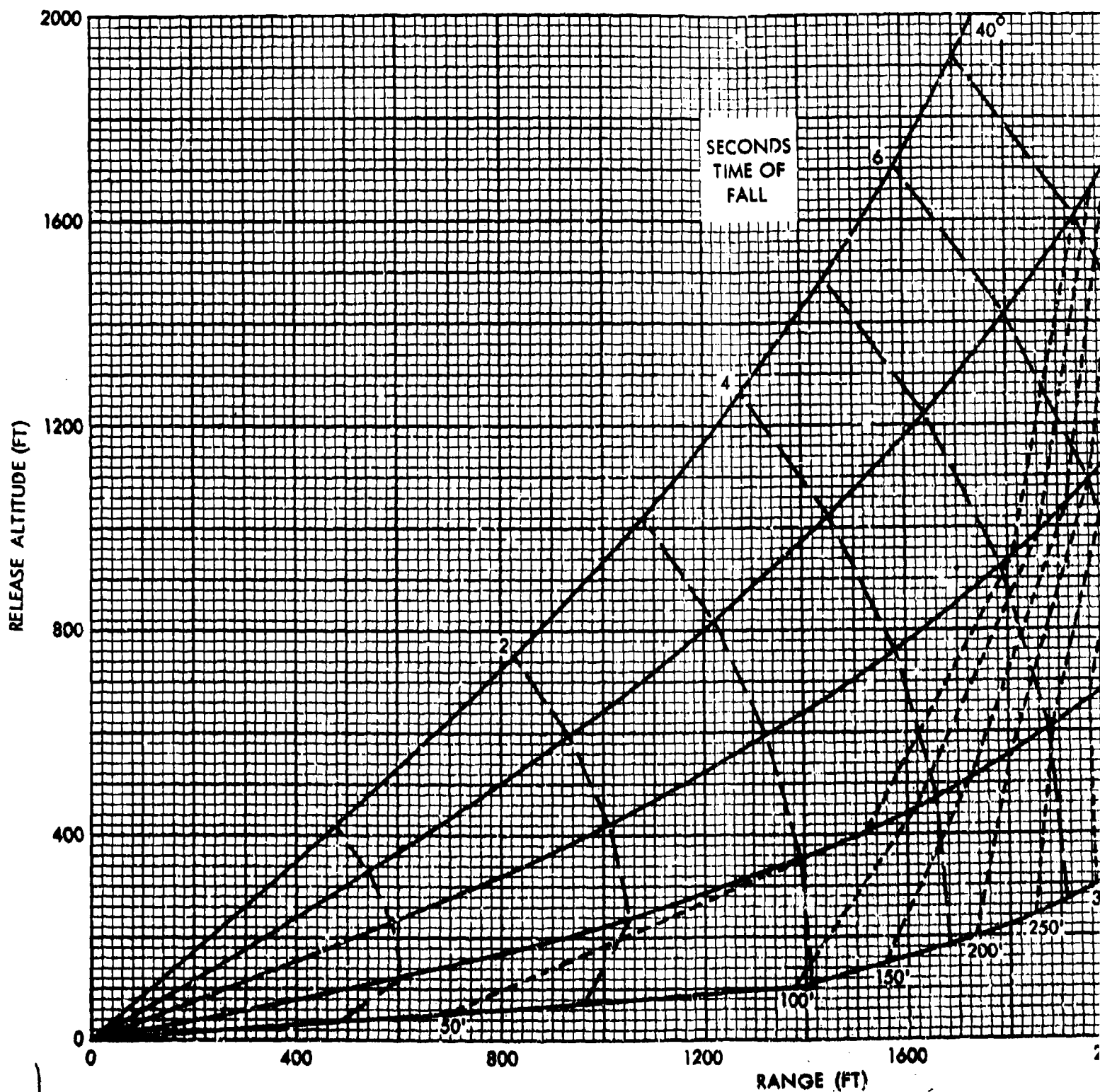


FIG. 12 MK 81/RETARDED EJ VEL O FPS

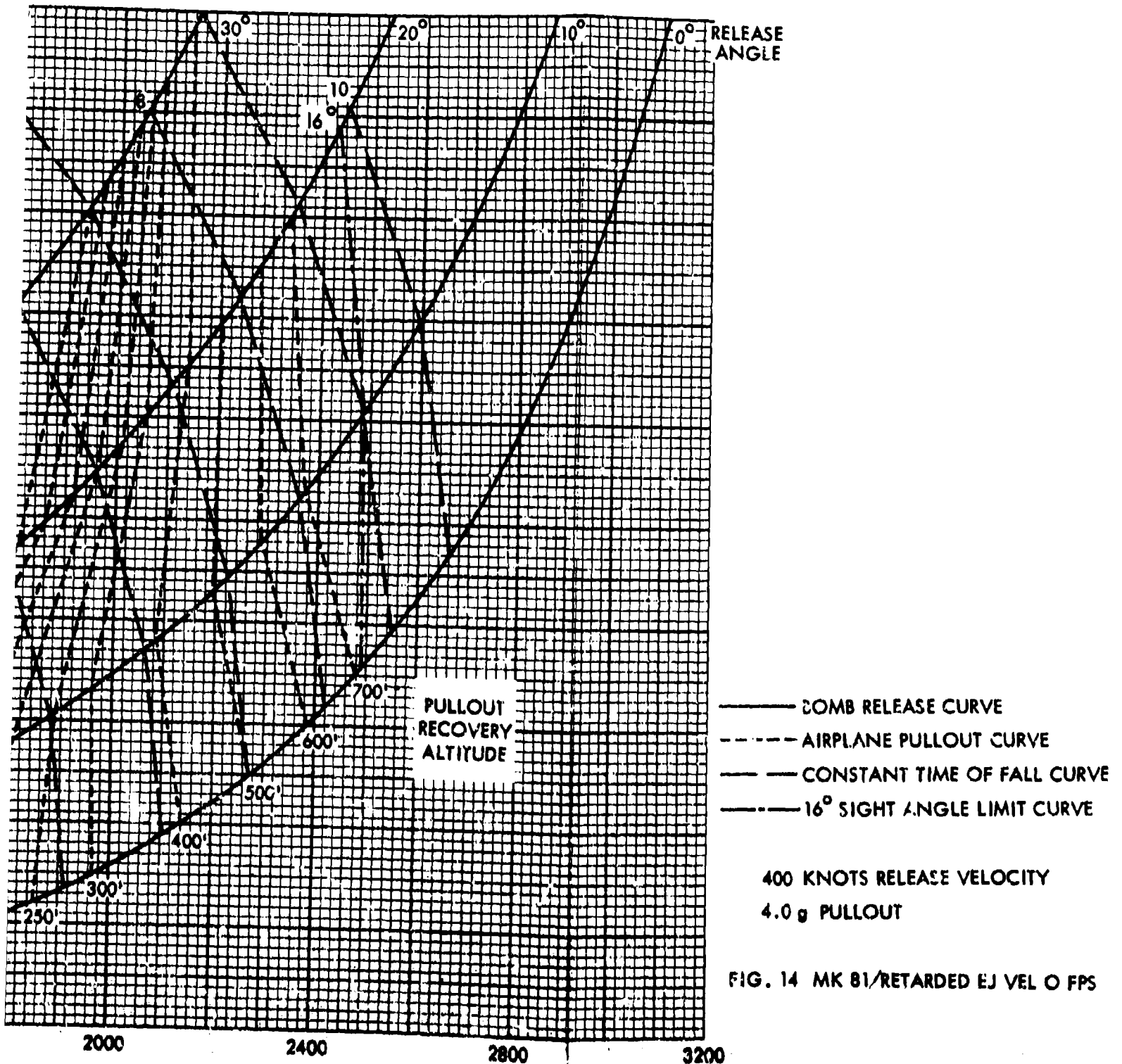


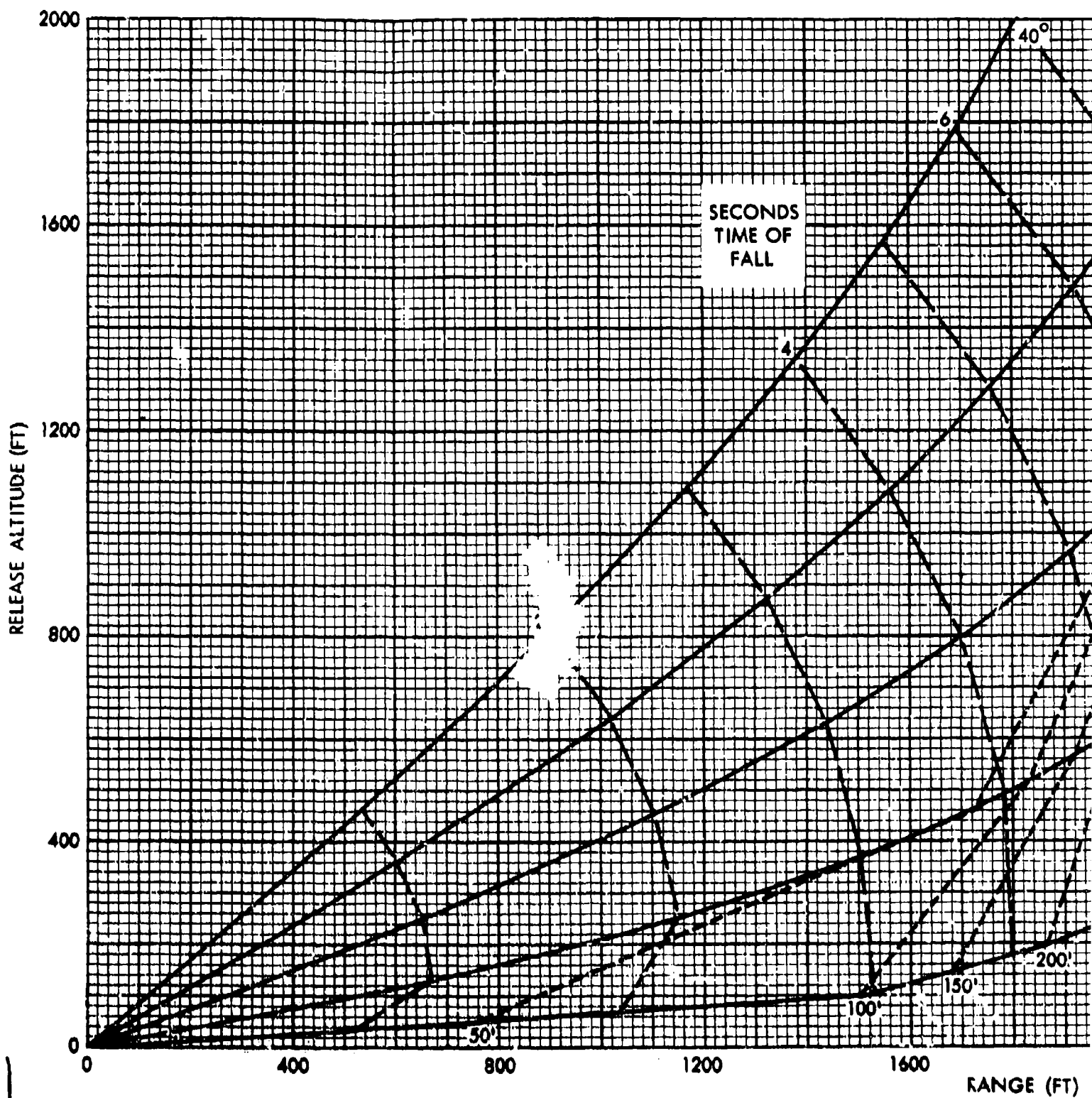


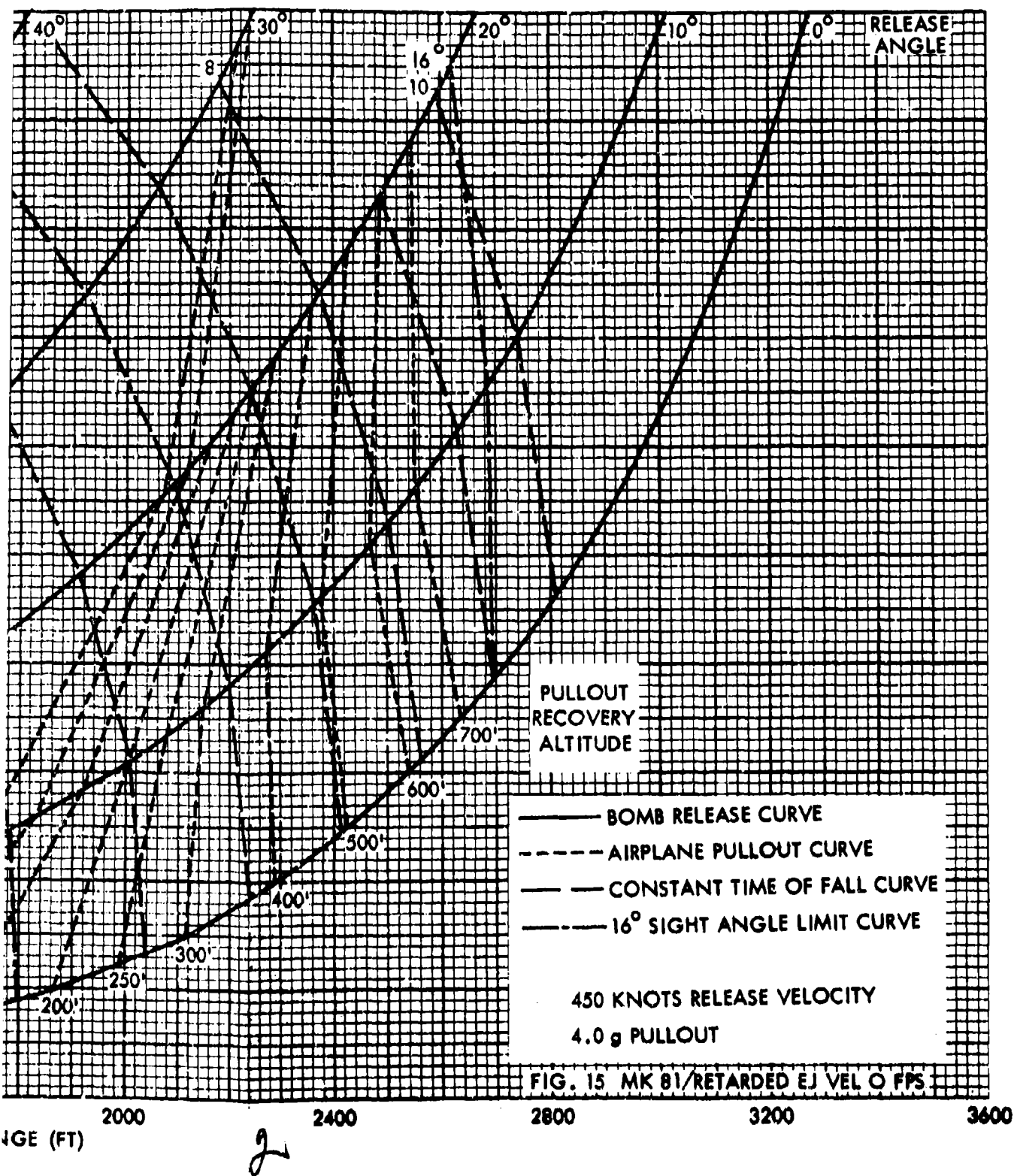
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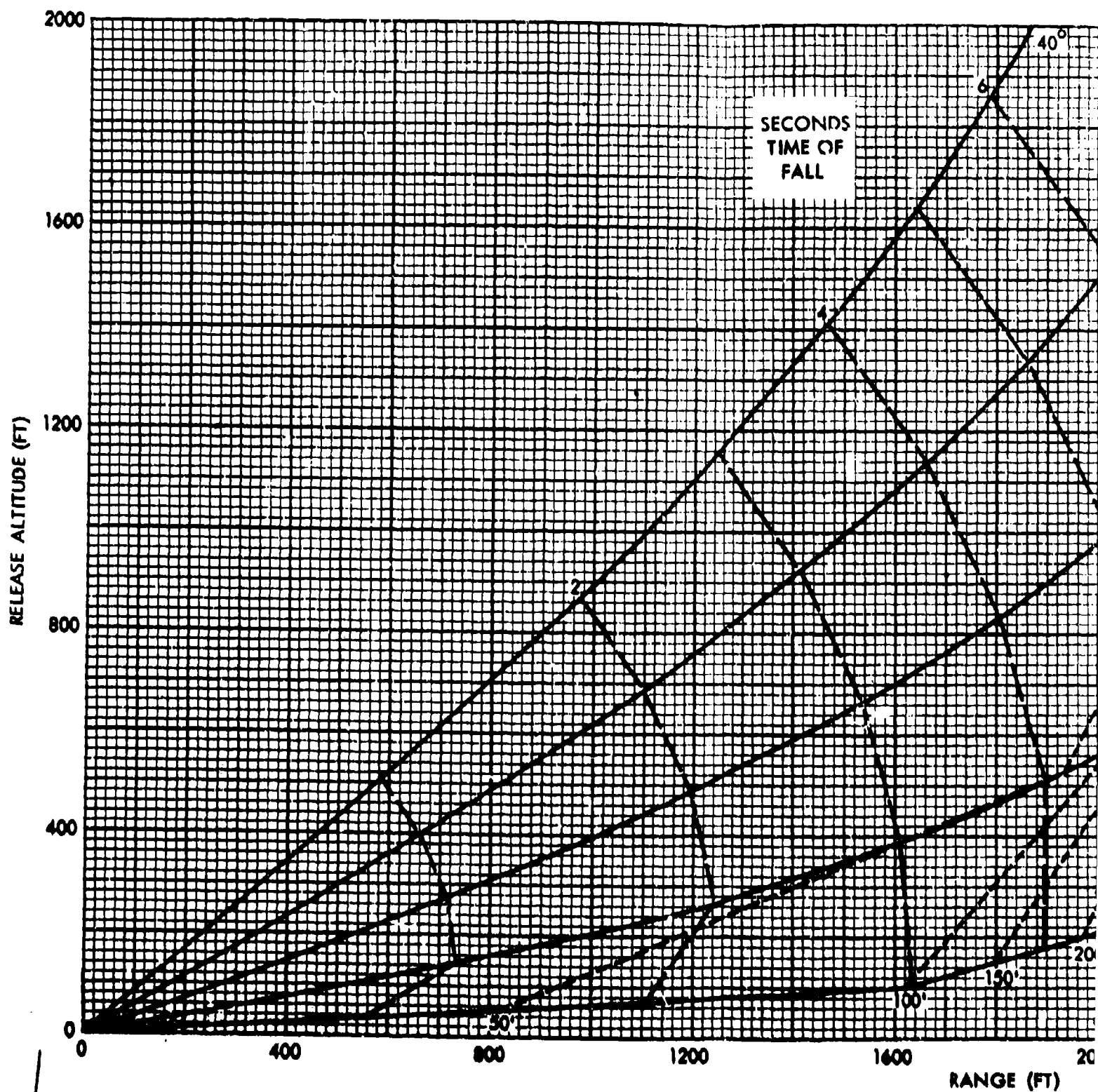


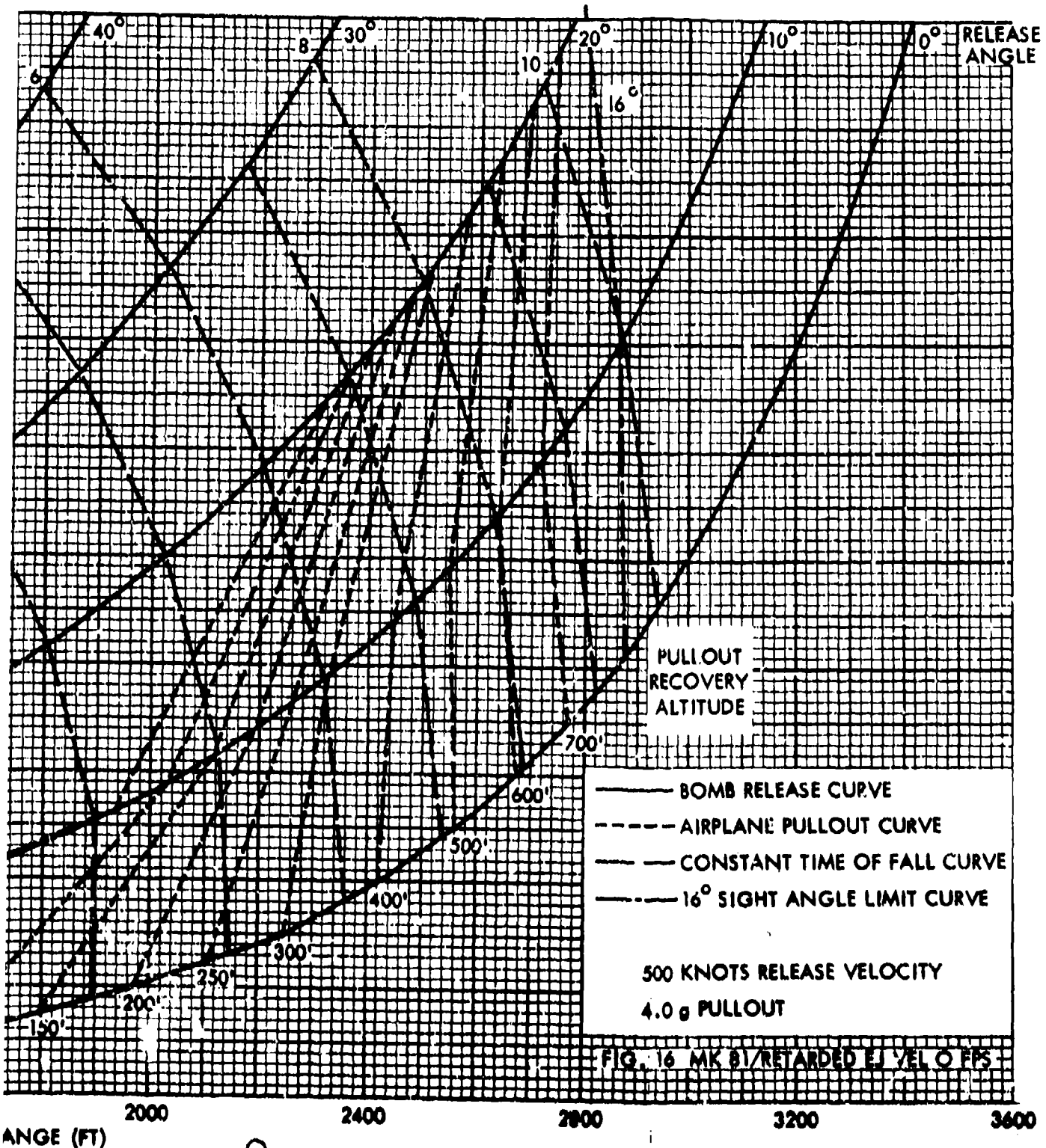
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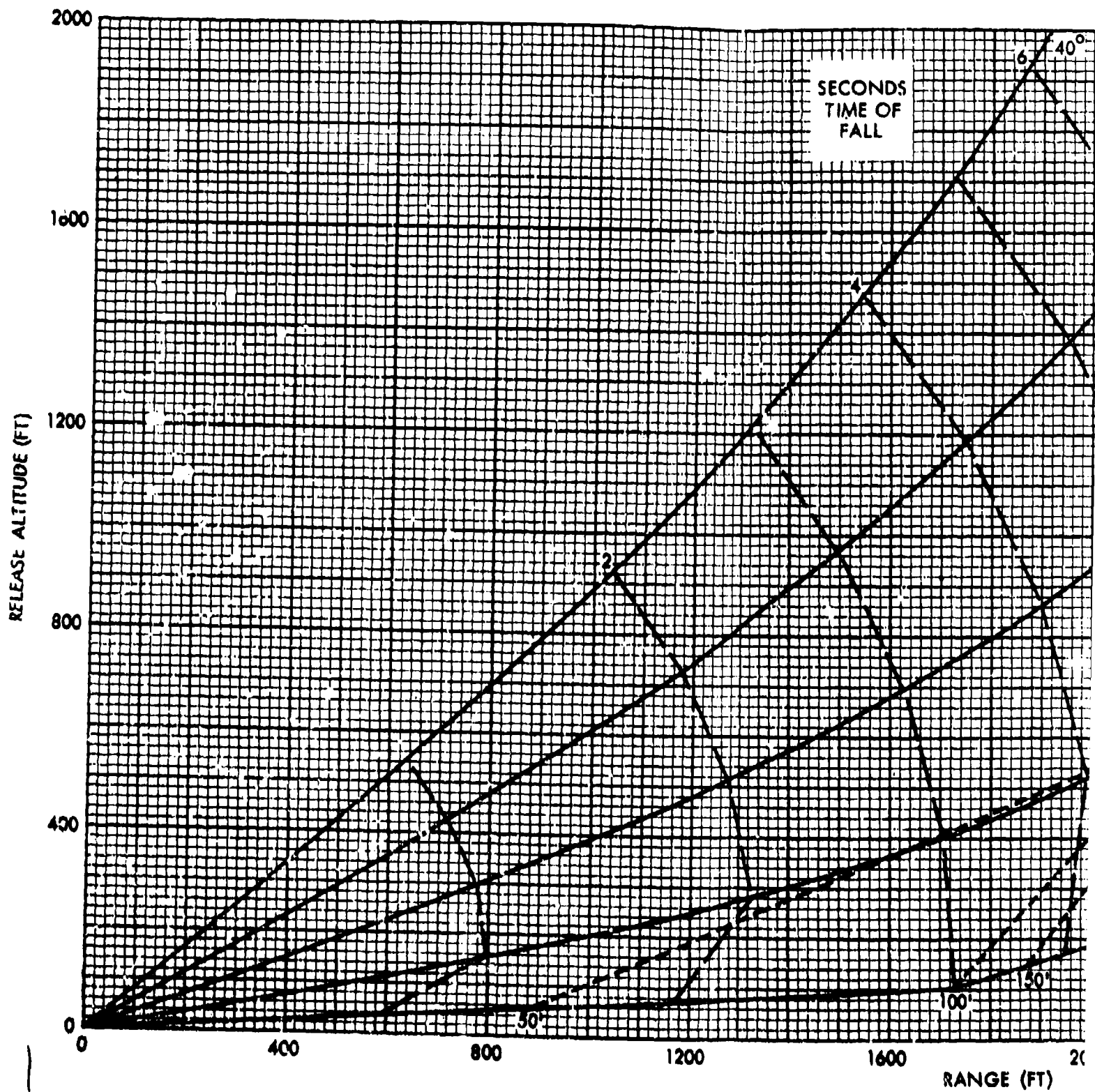


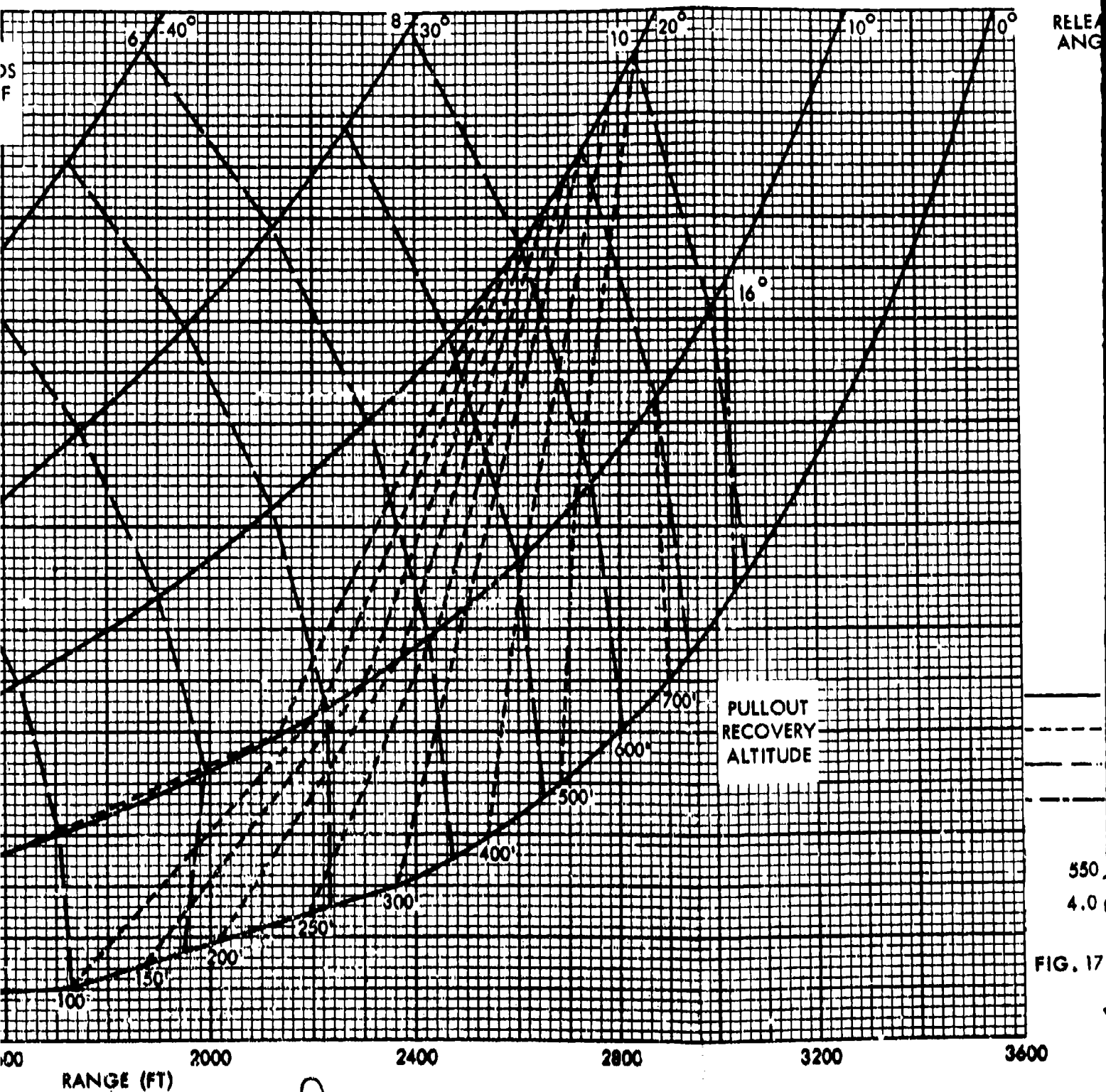






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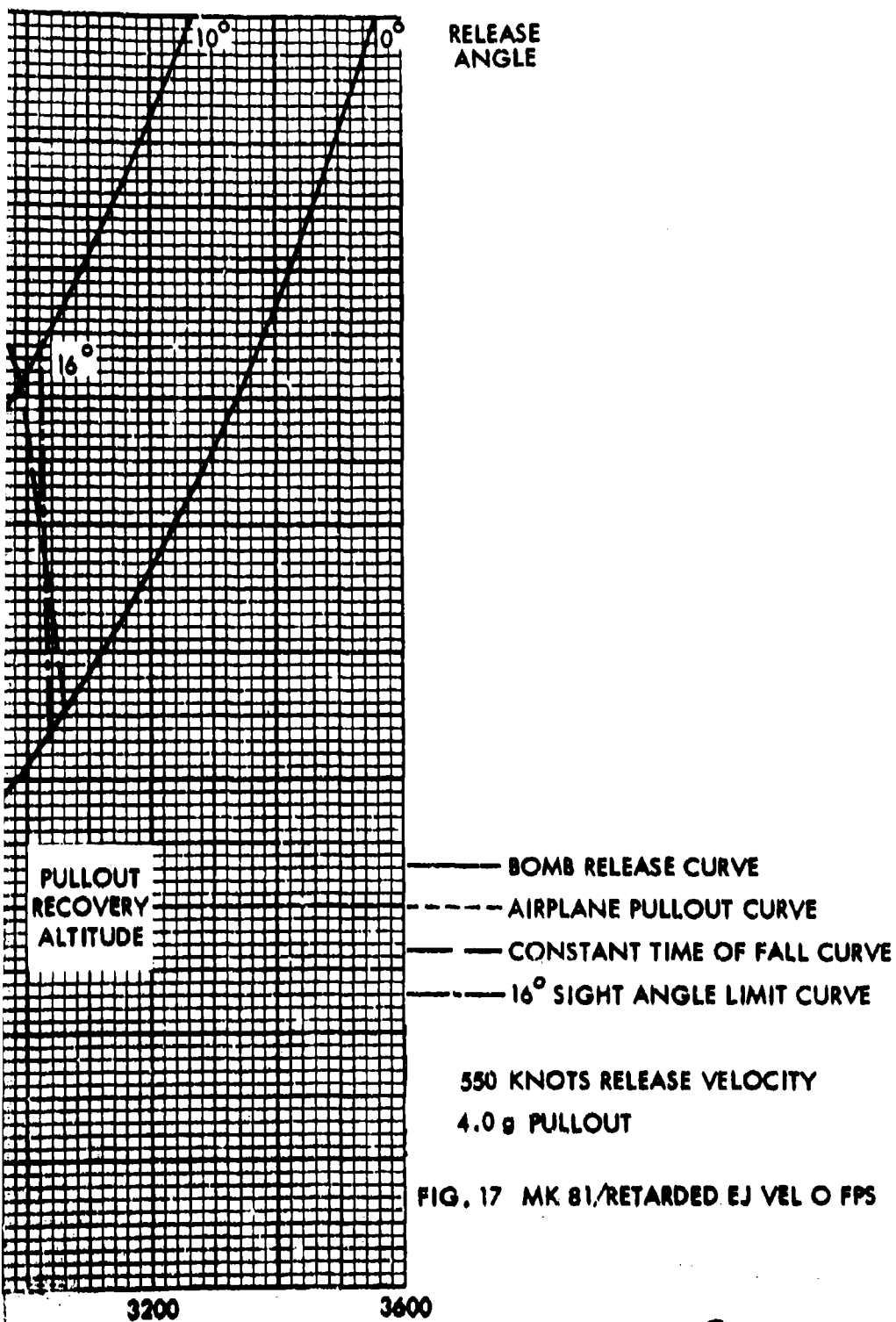
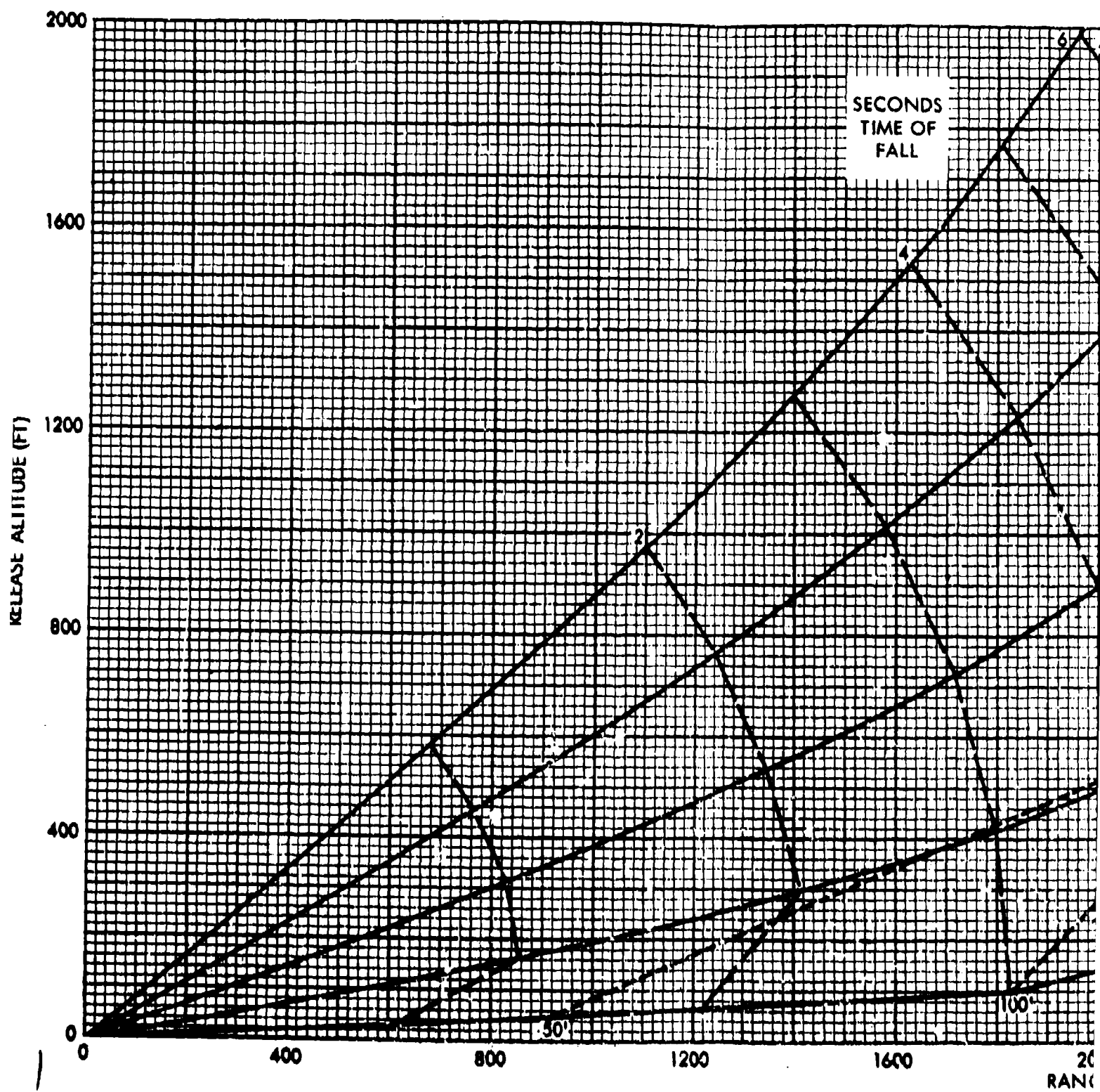
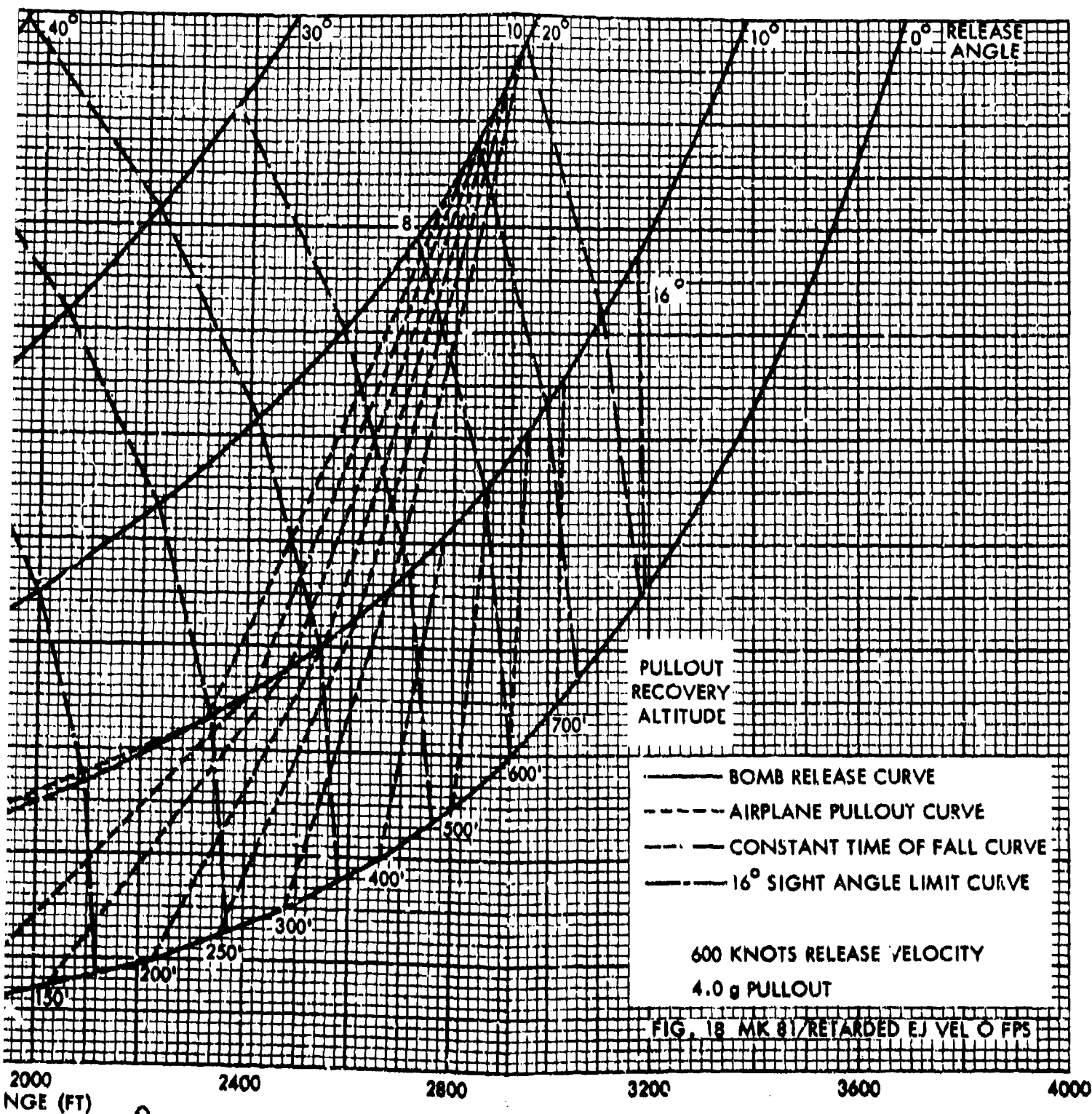
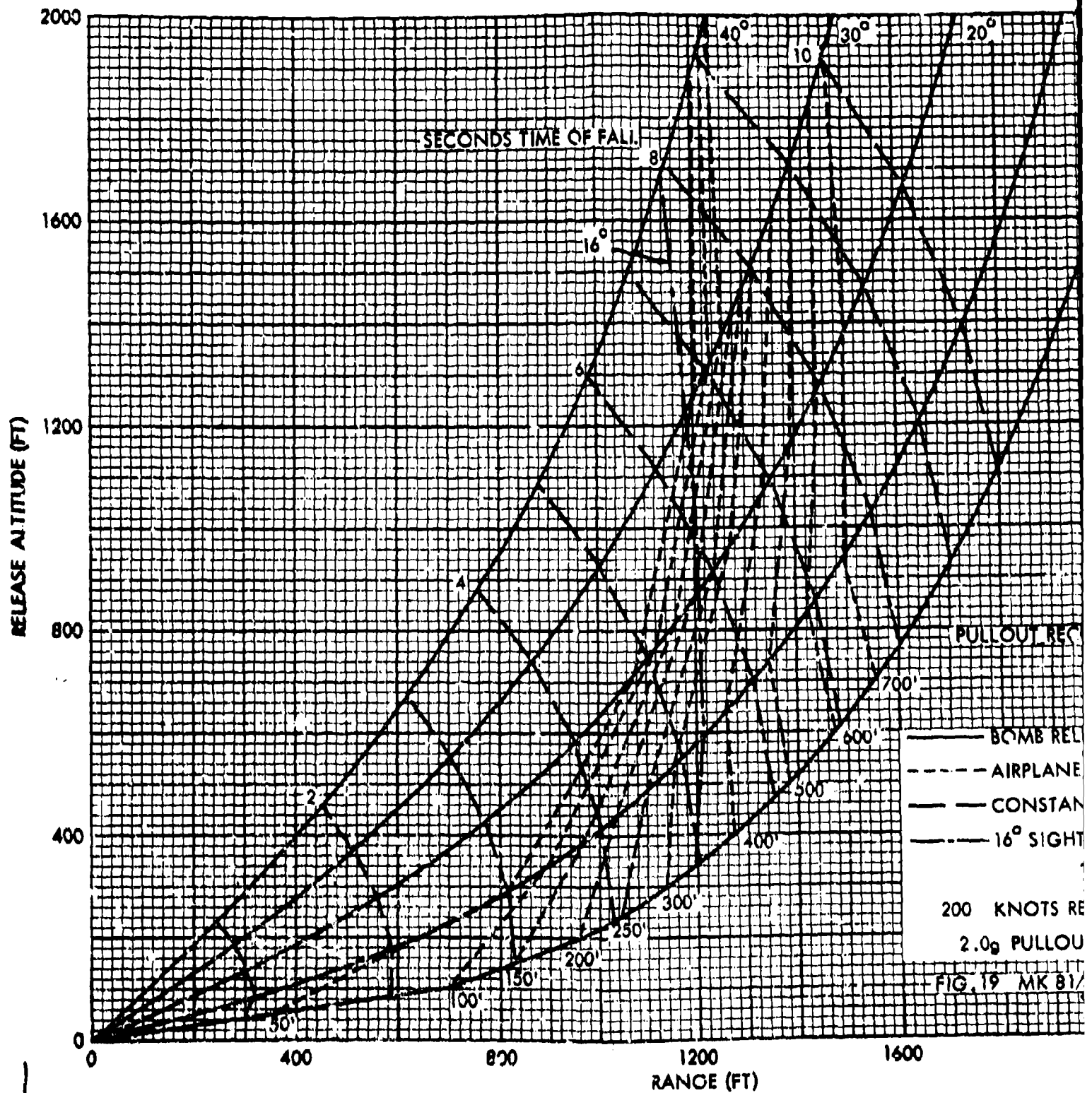


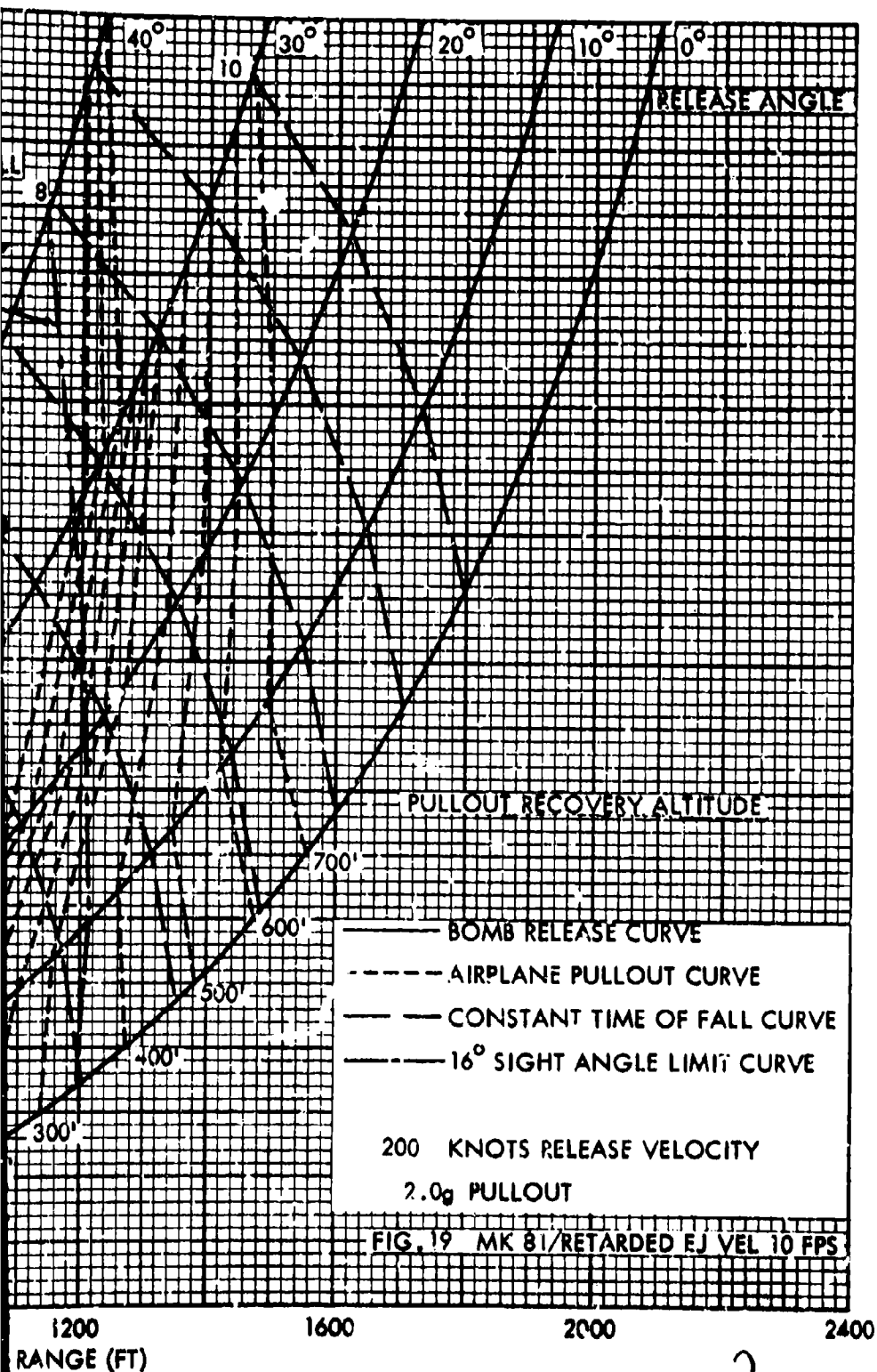
FIG. 17 MK 81/RETARDED EJ VEL O FPS

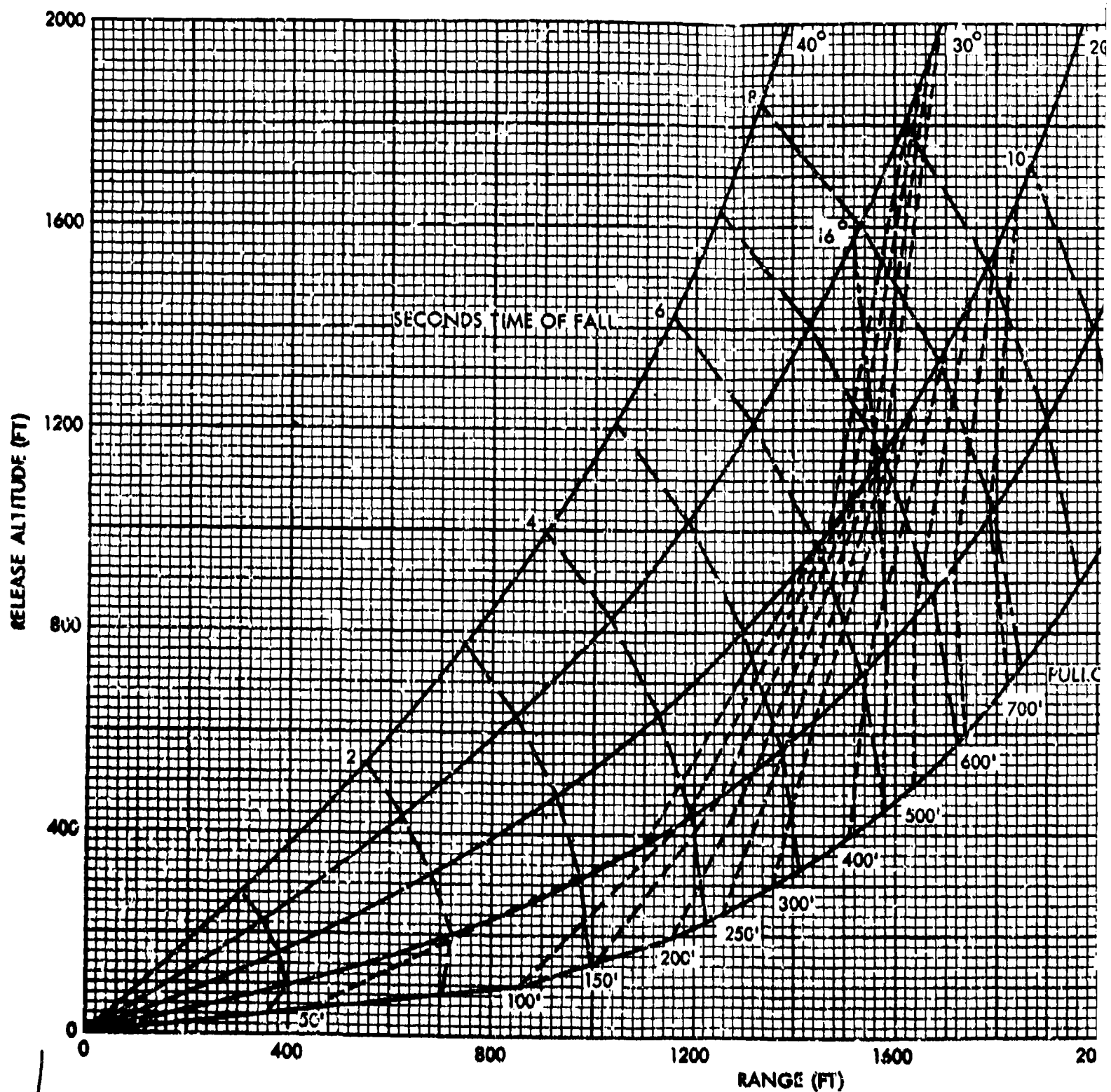




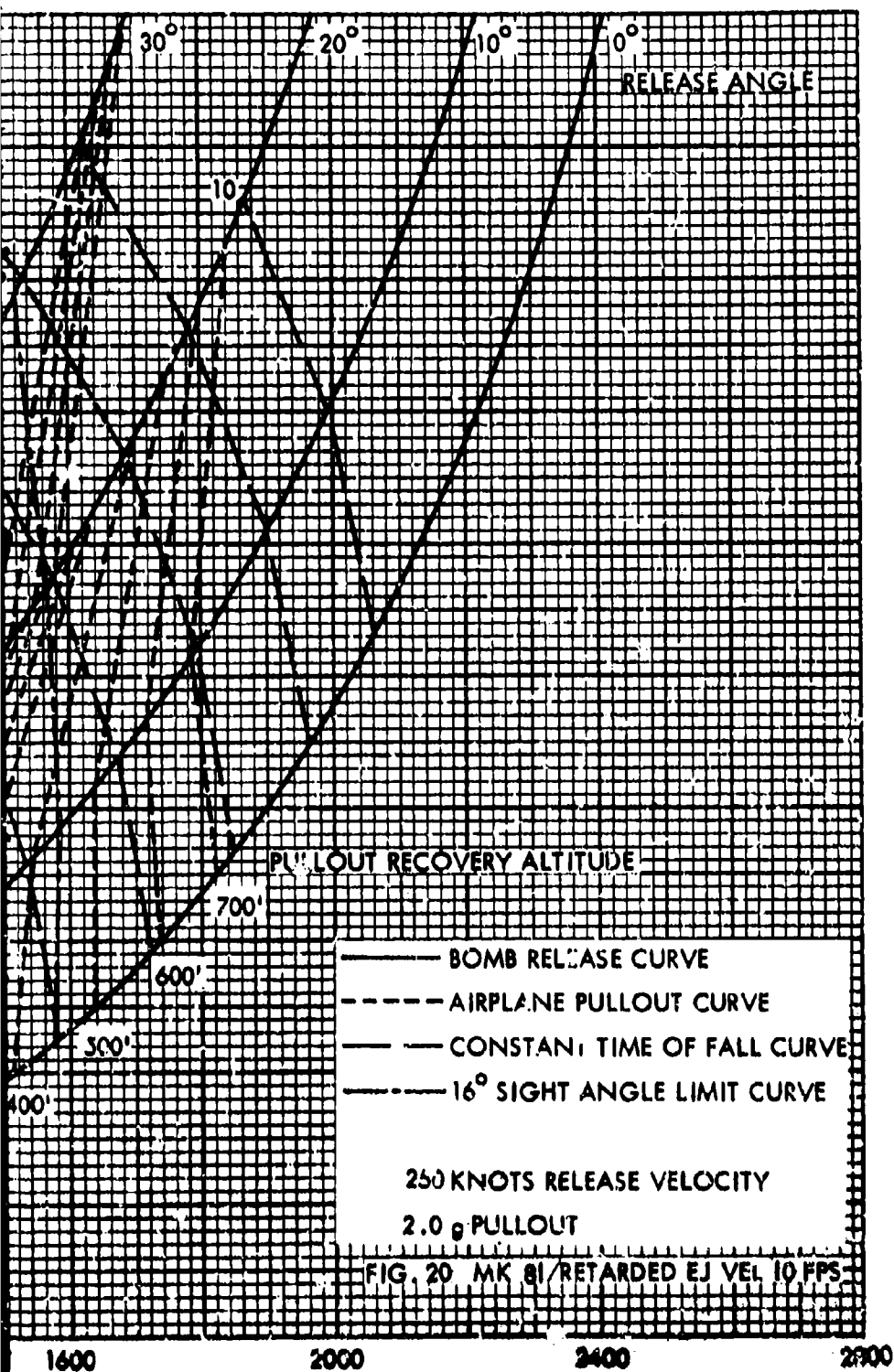


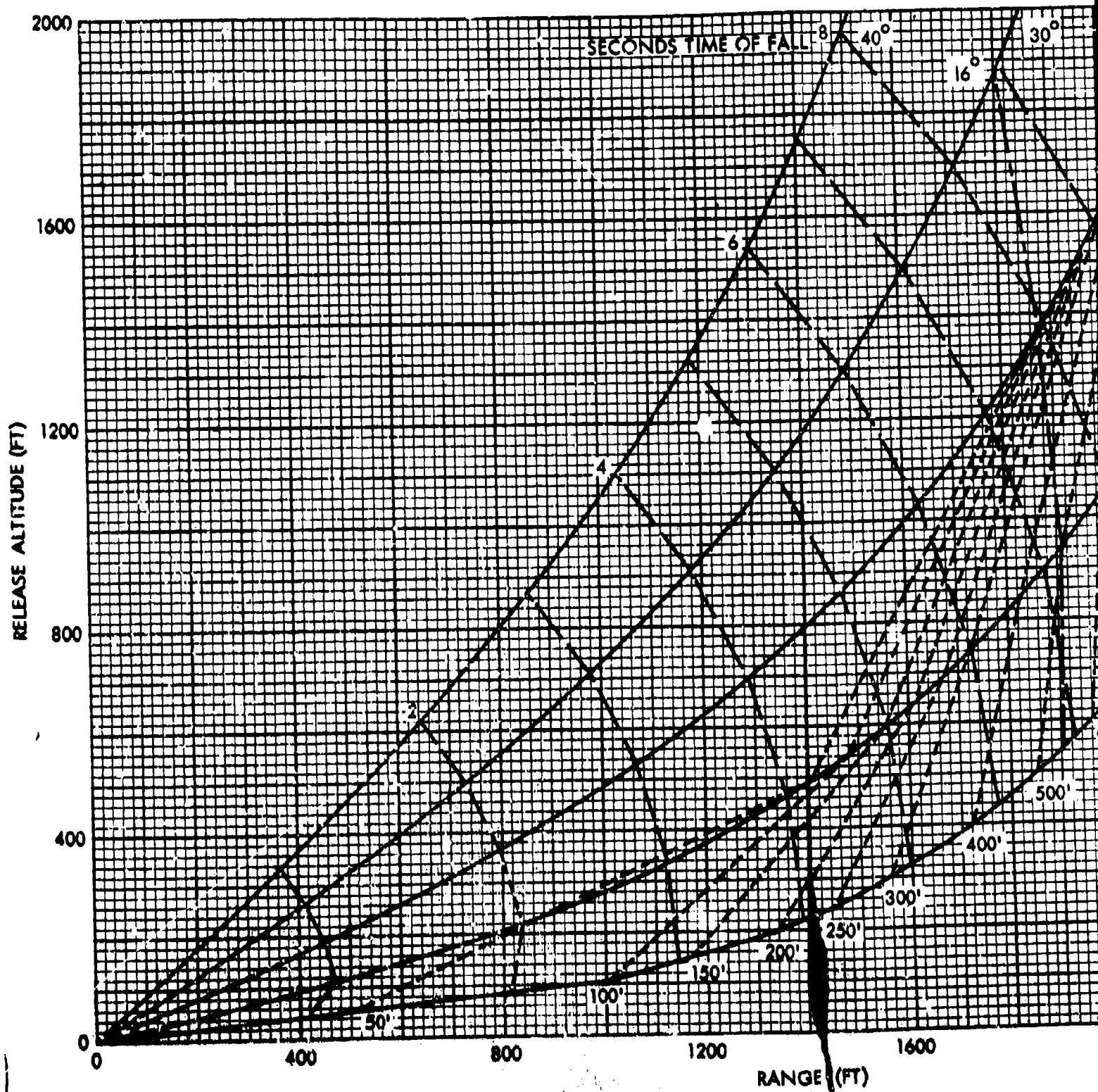
NOLTR 65-230



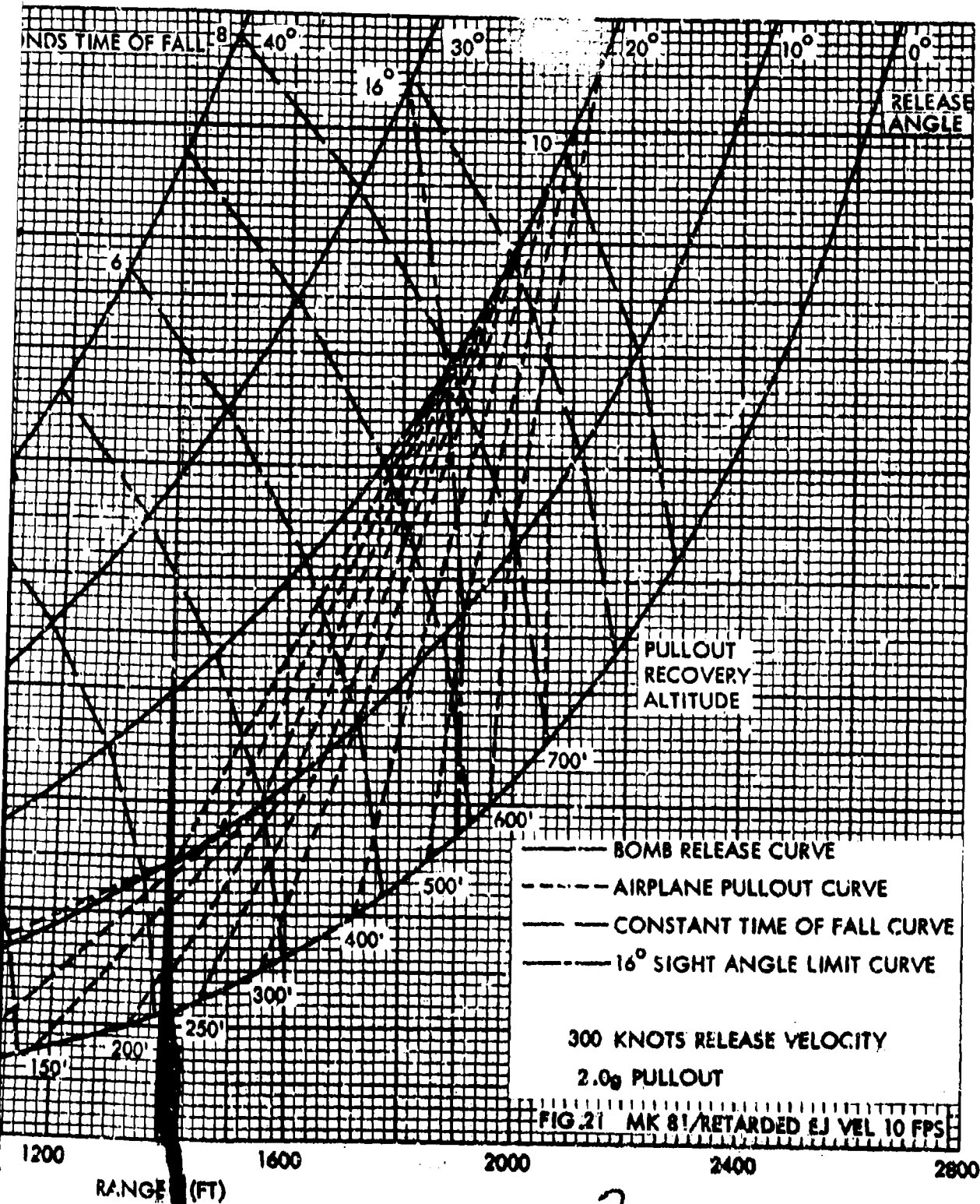


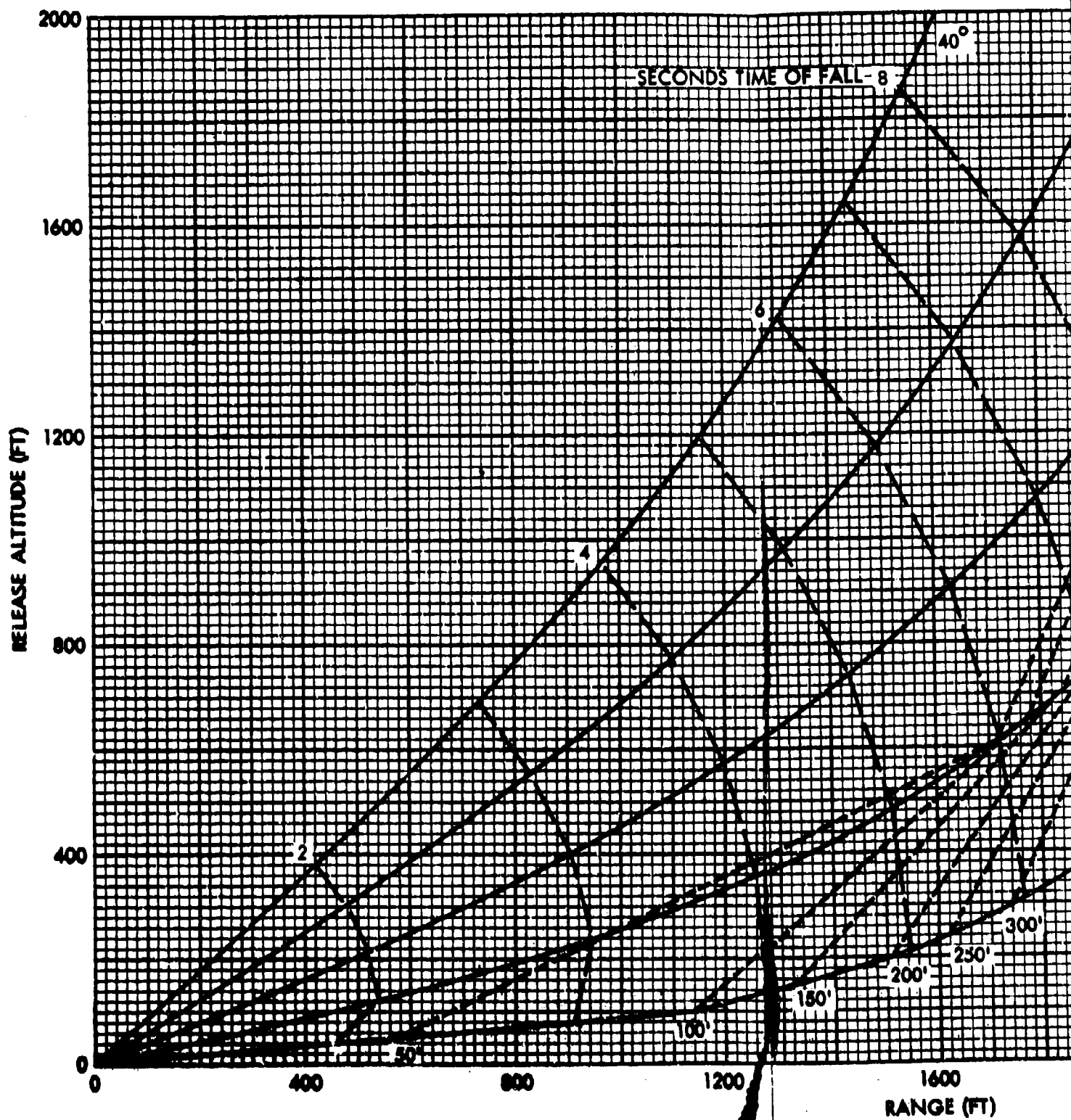
NOLTR 65-230

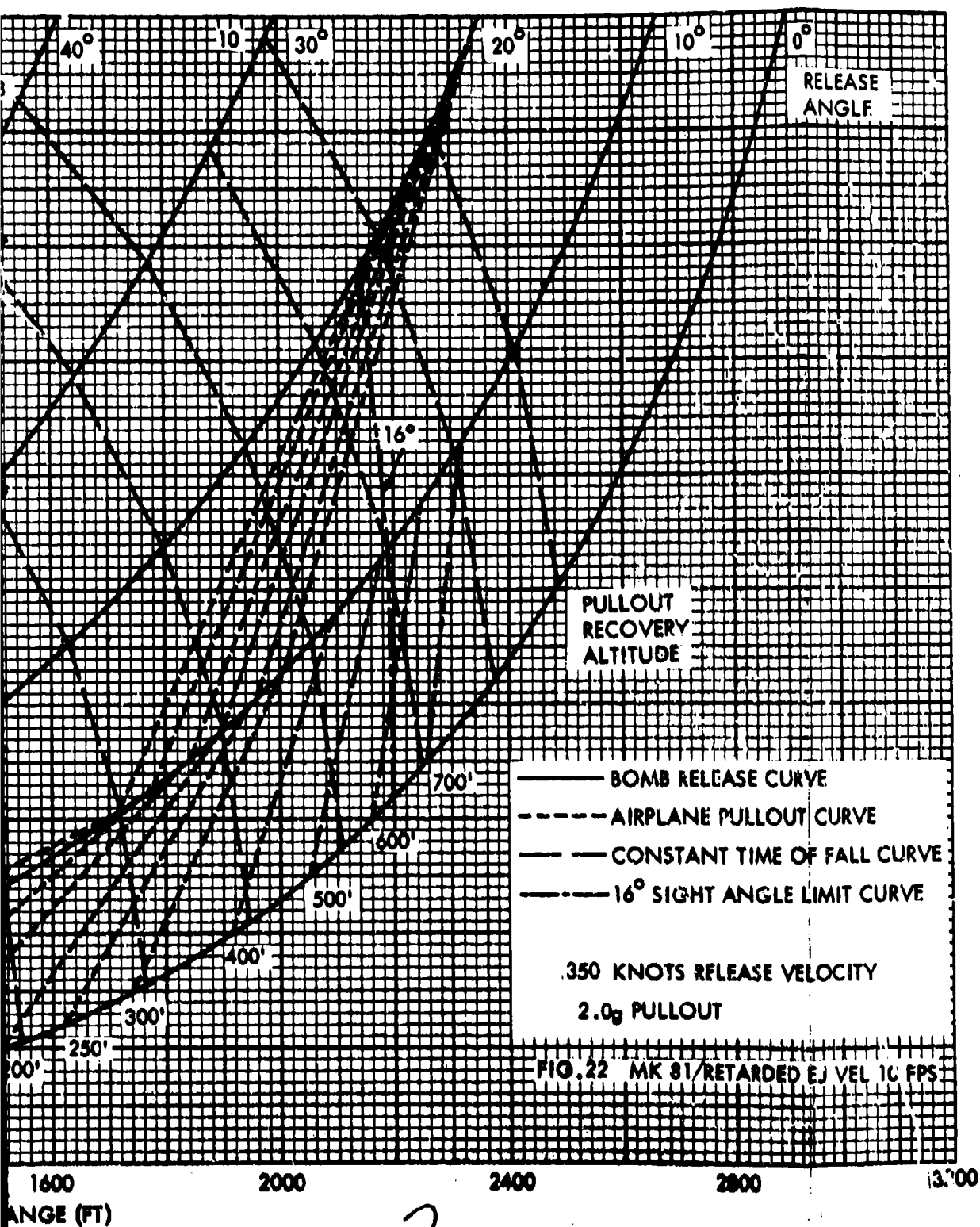


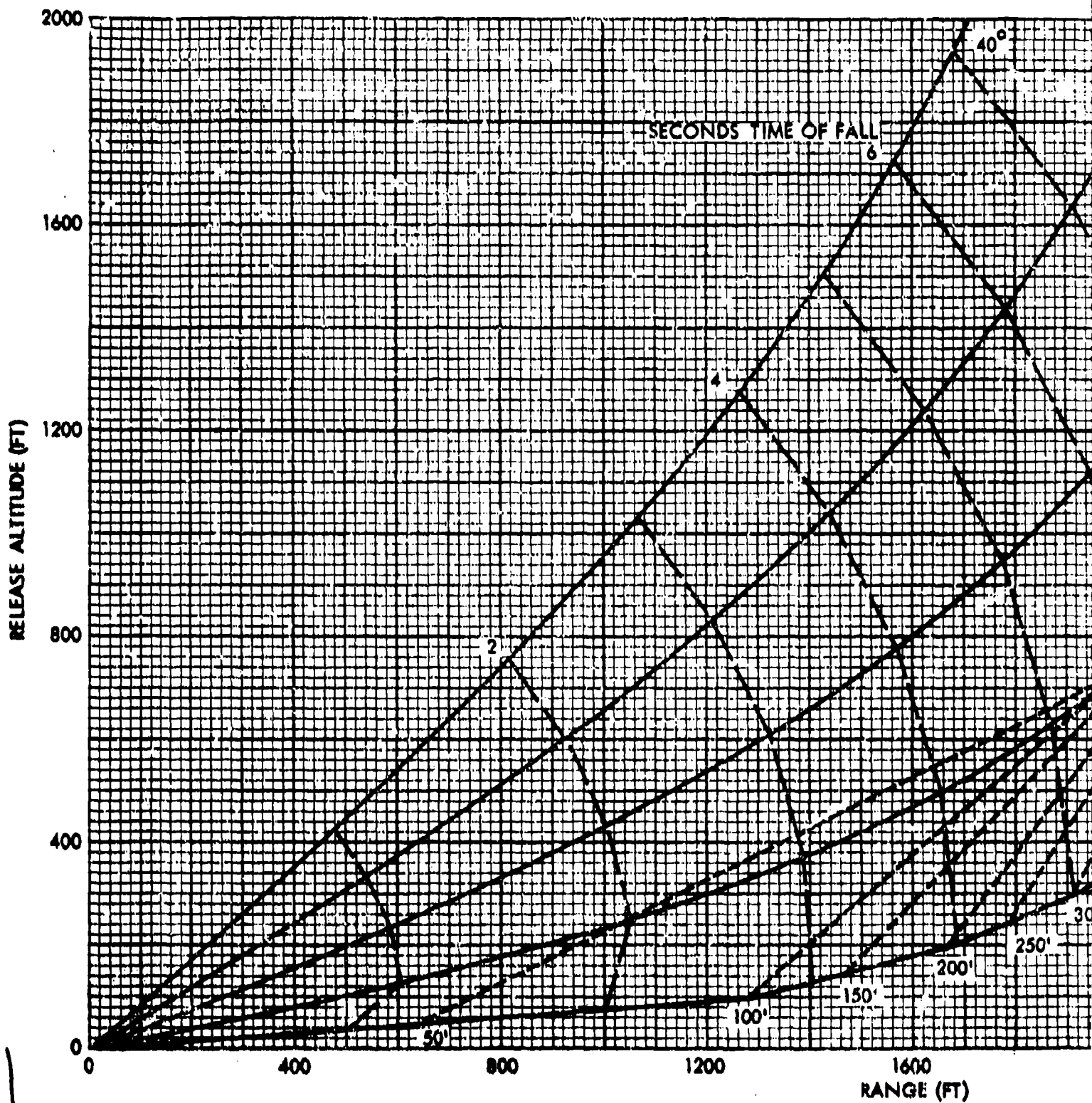


NOLTR 65-230

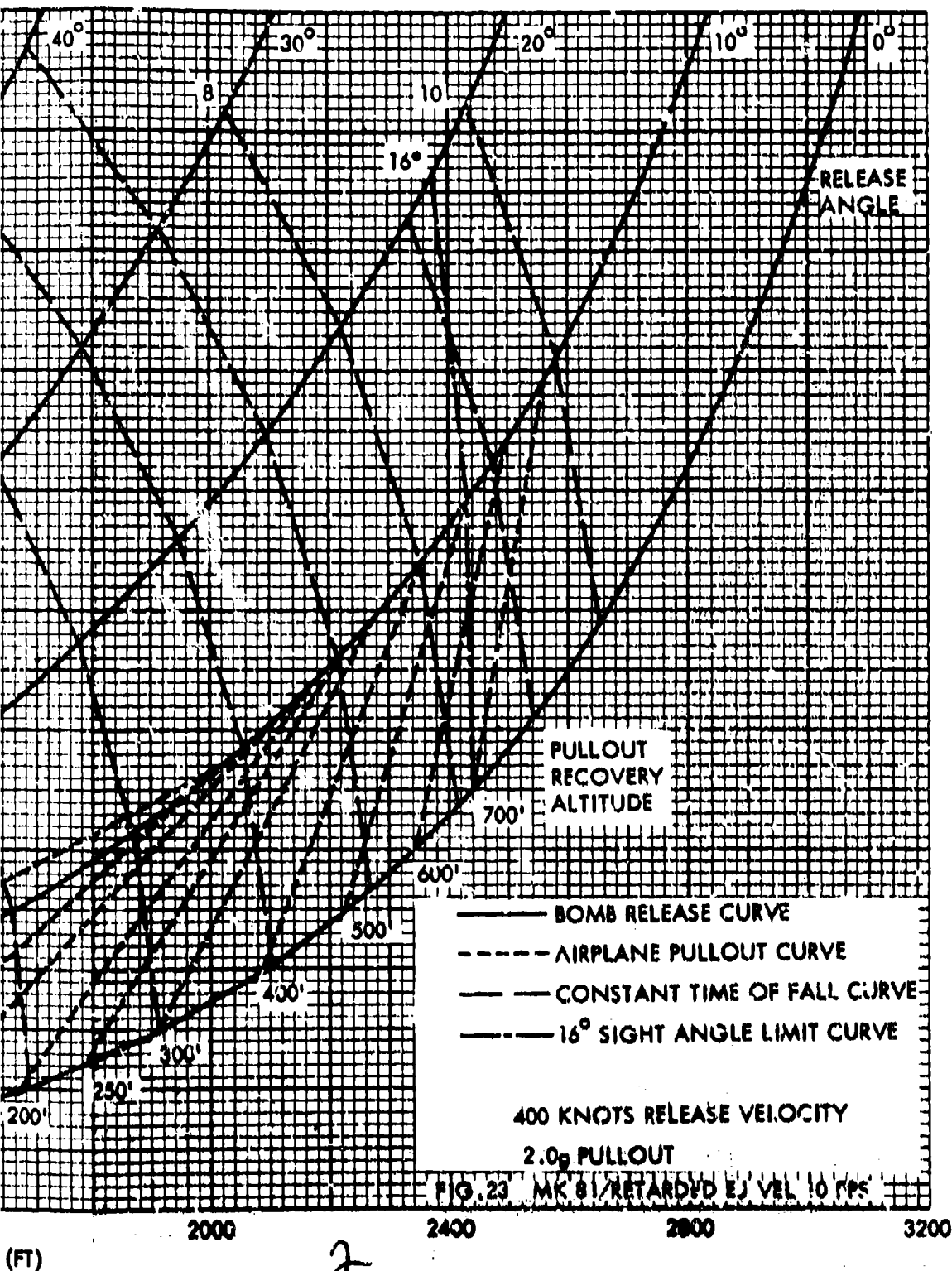


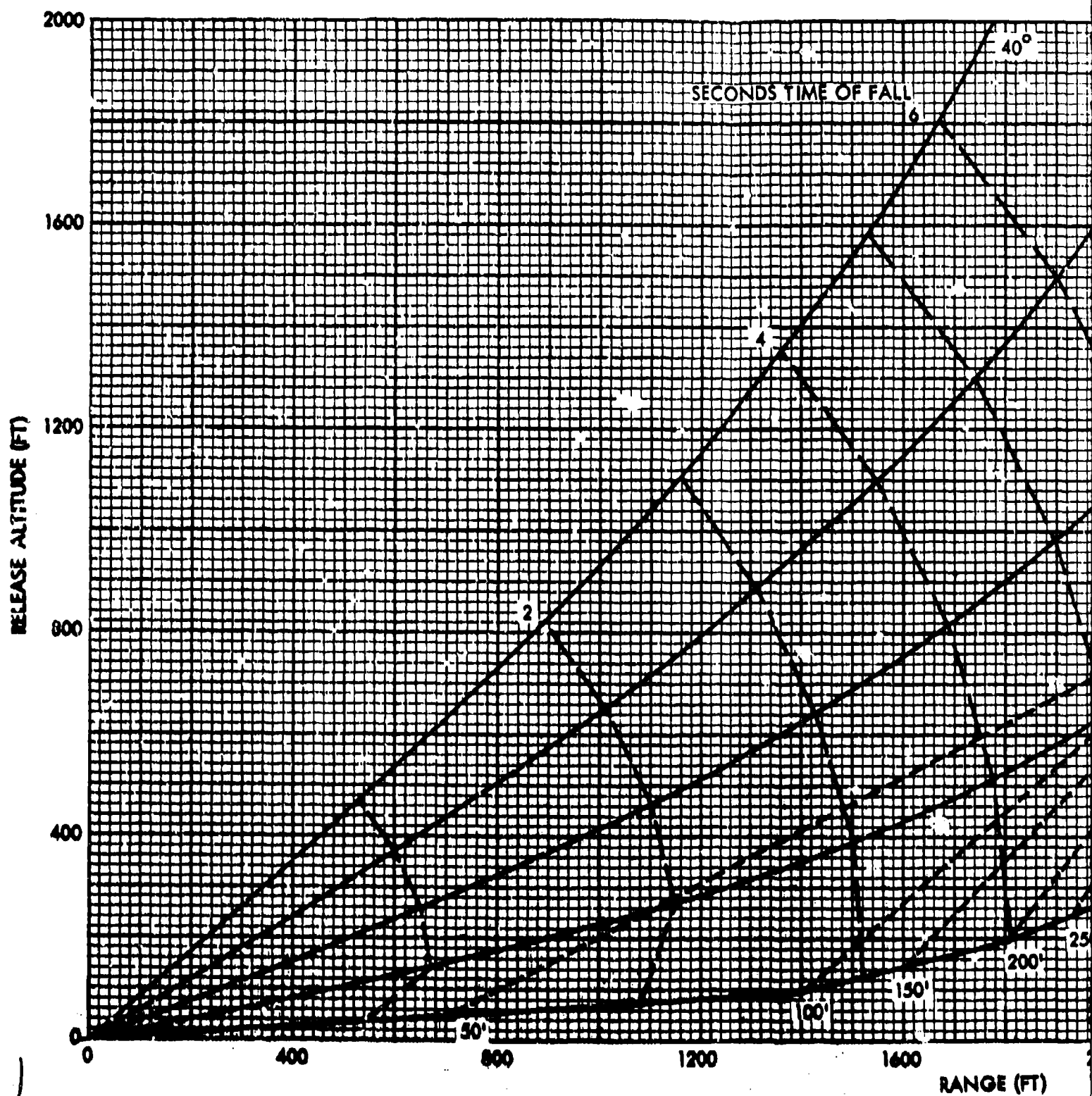


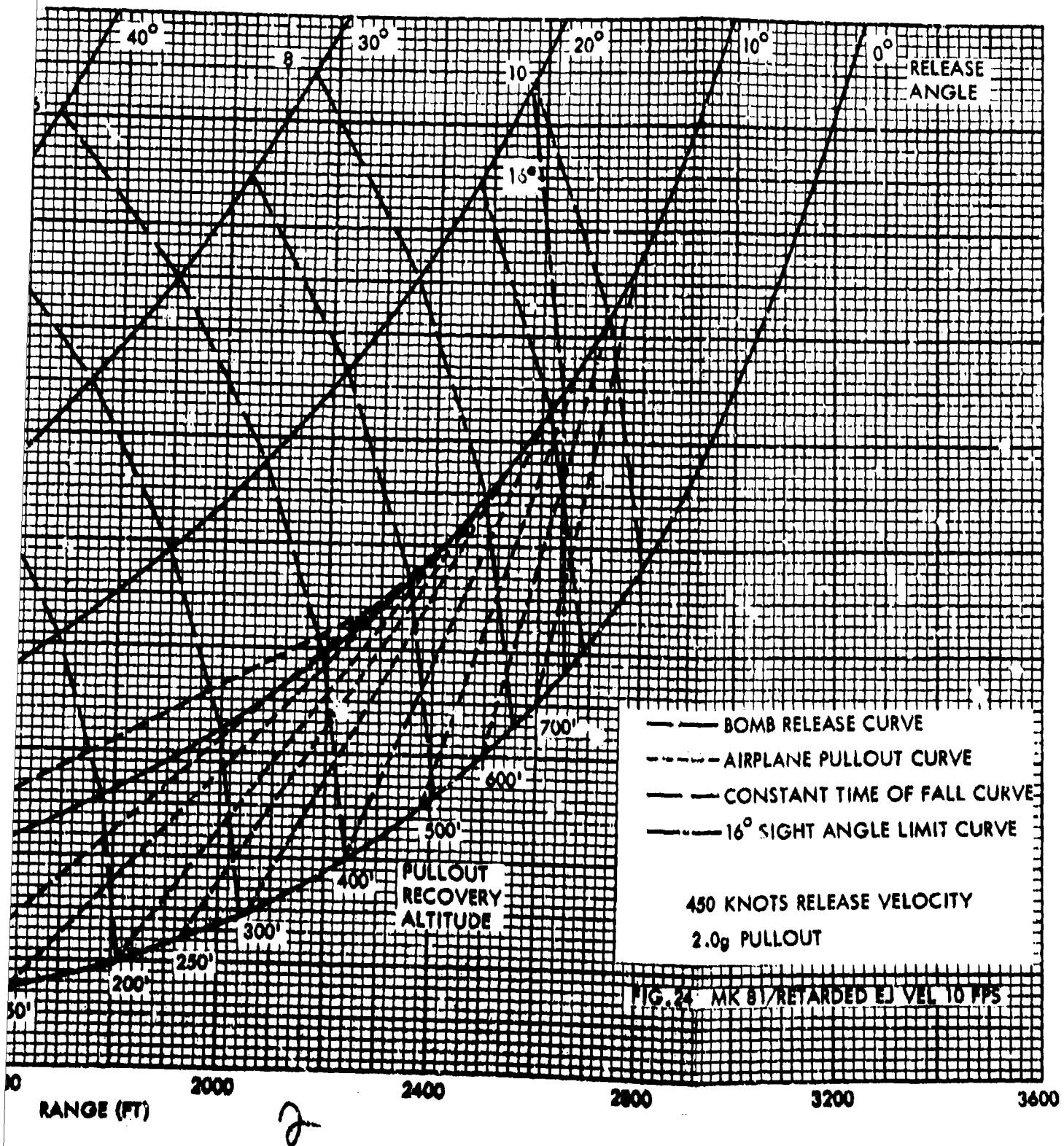


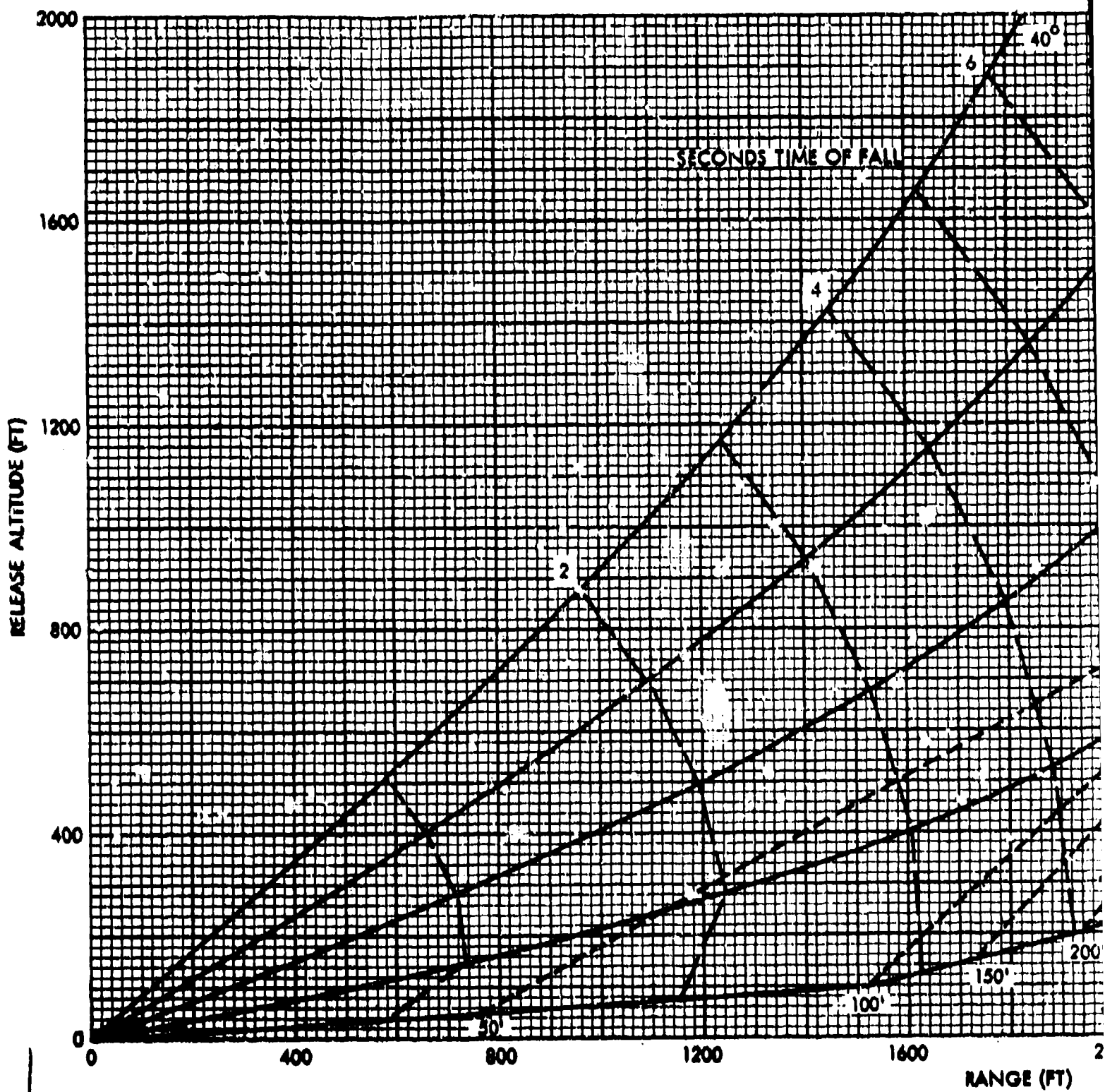


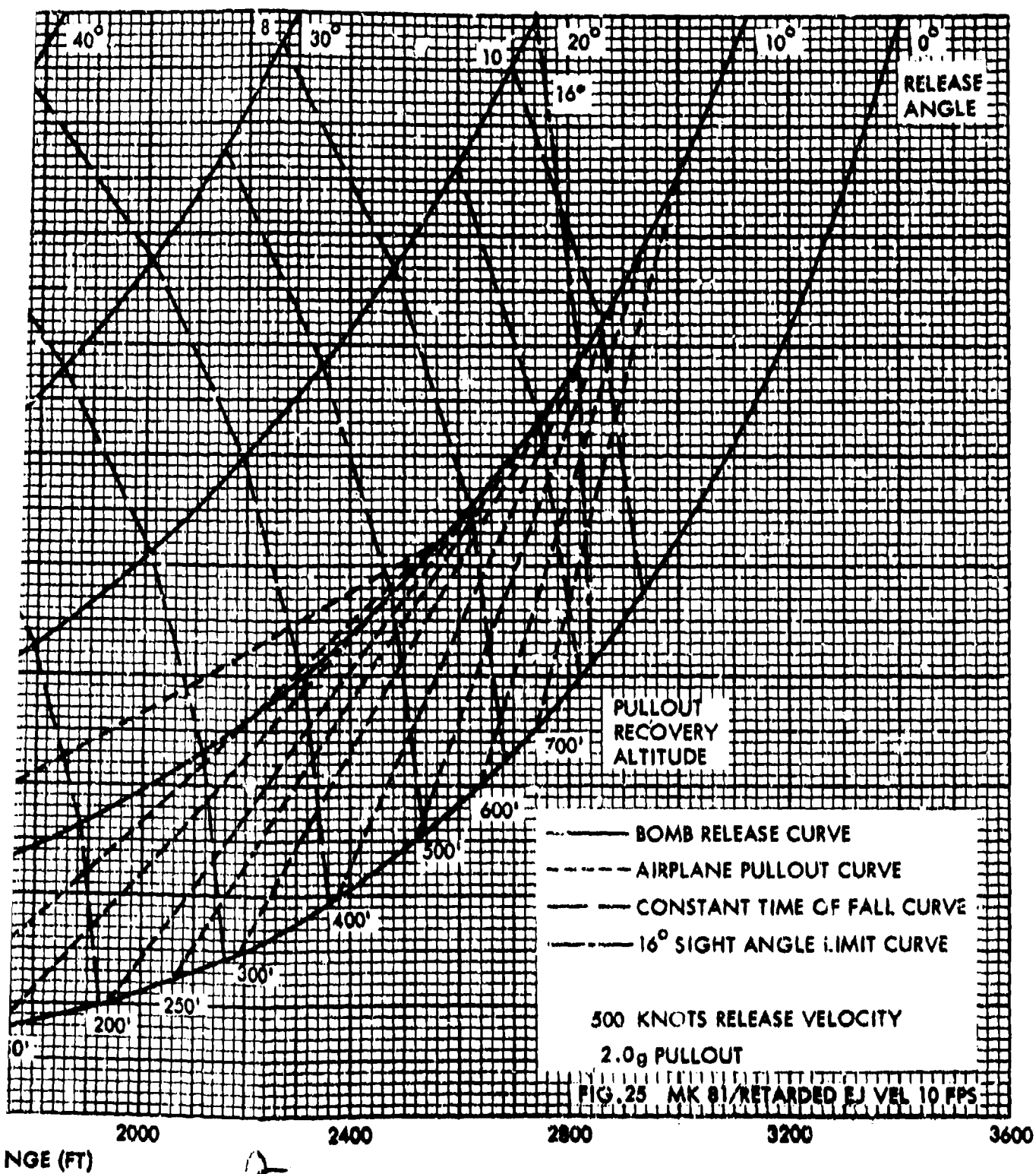
NOLTR 65-230

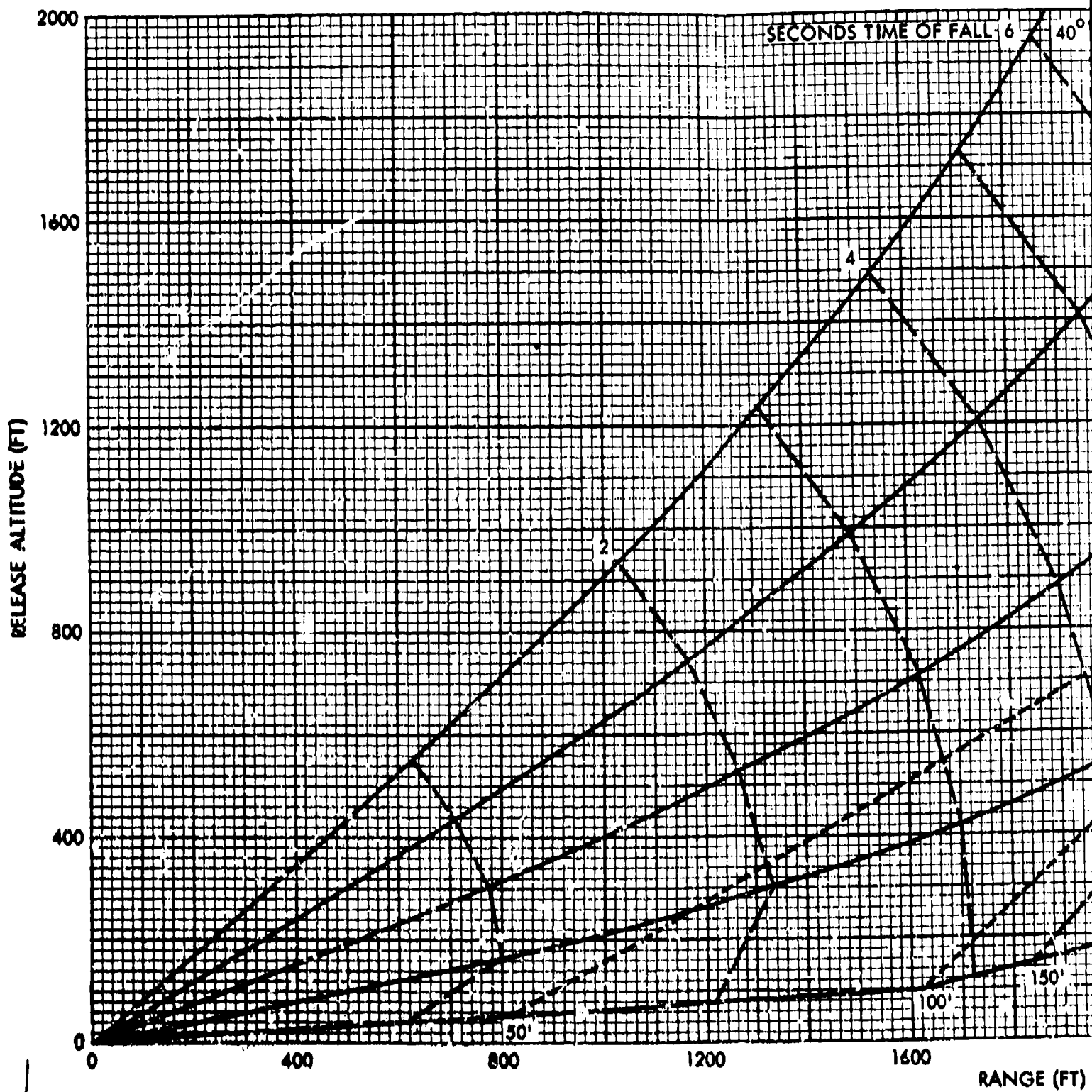


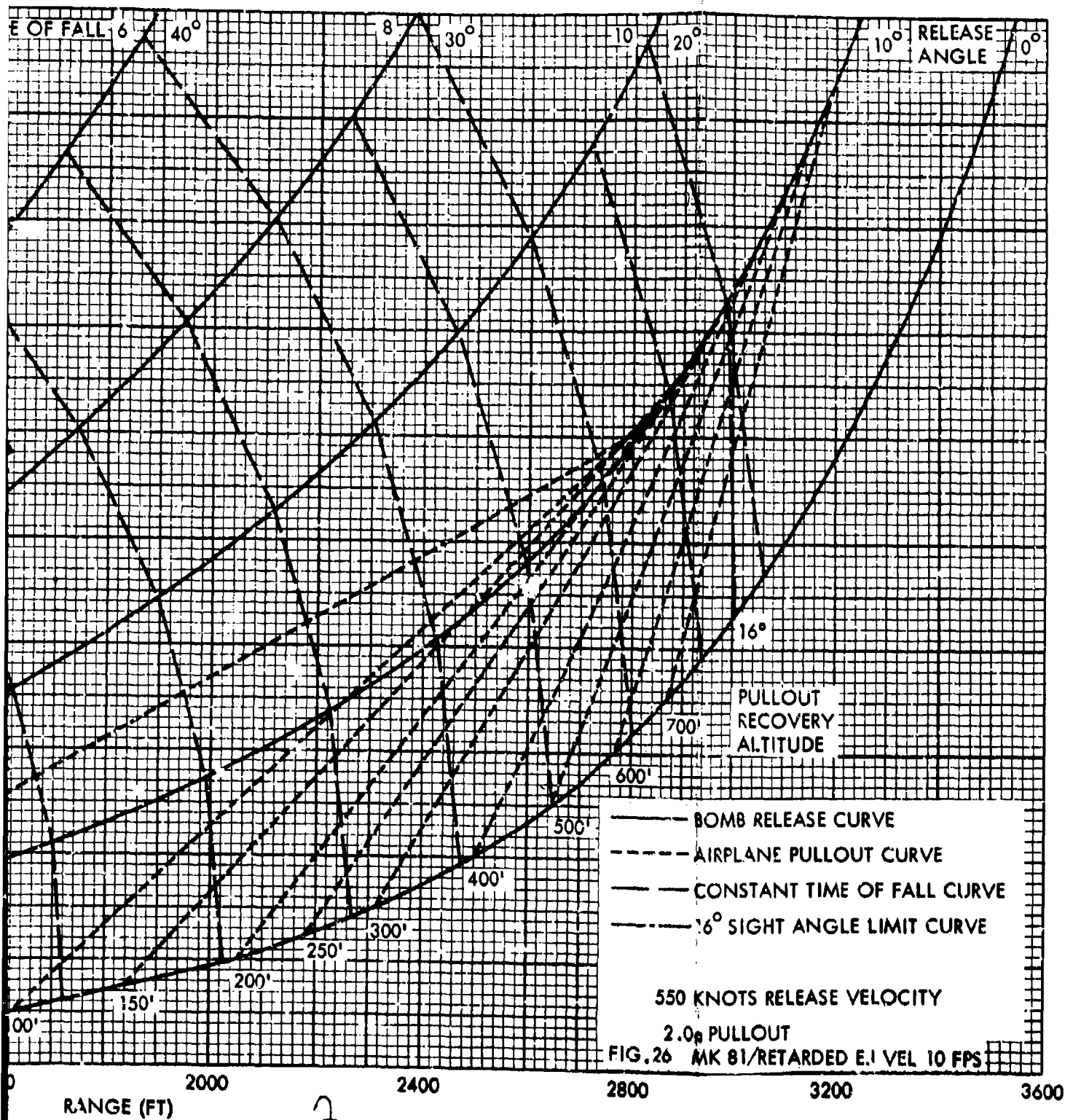


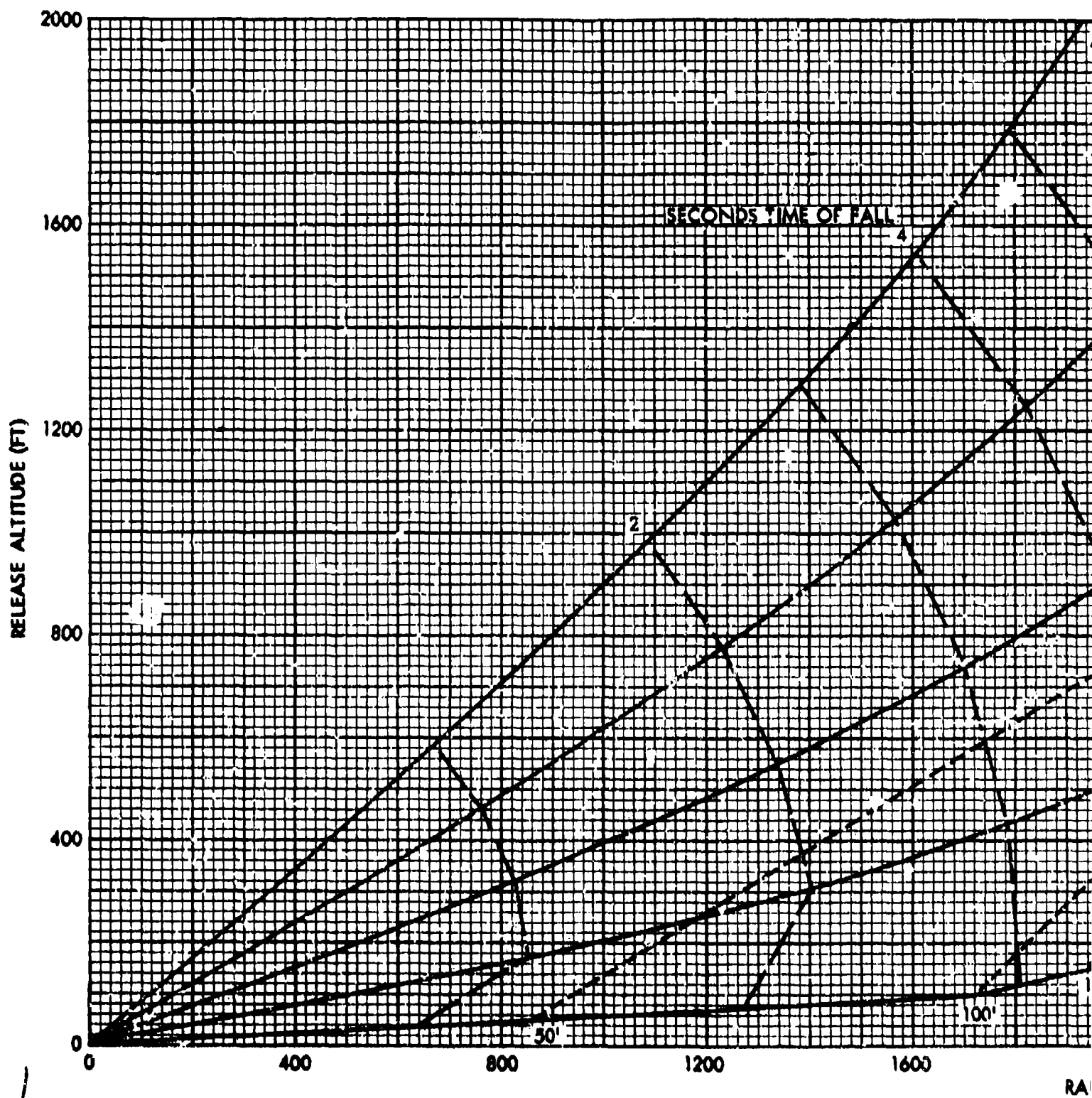


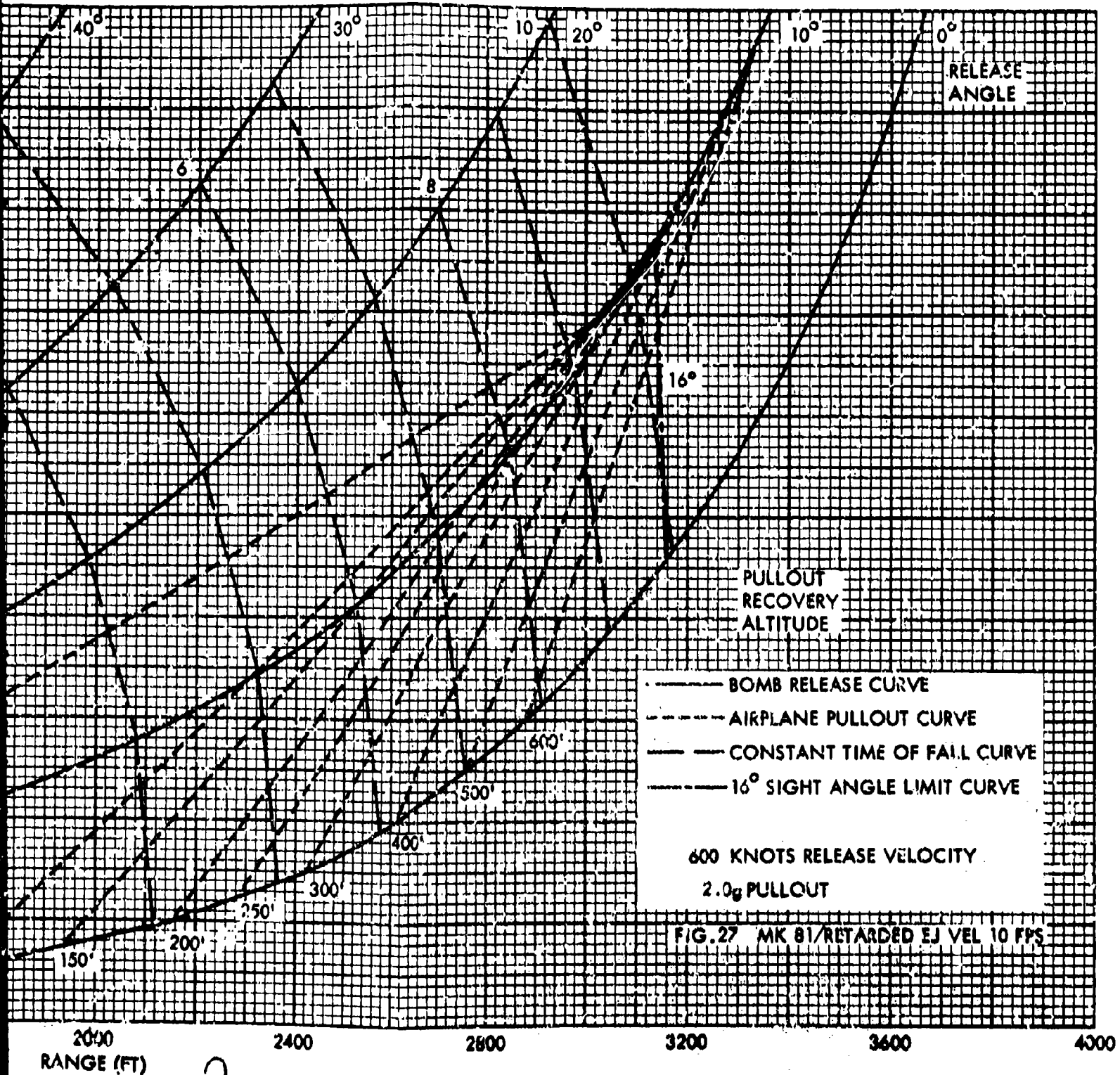


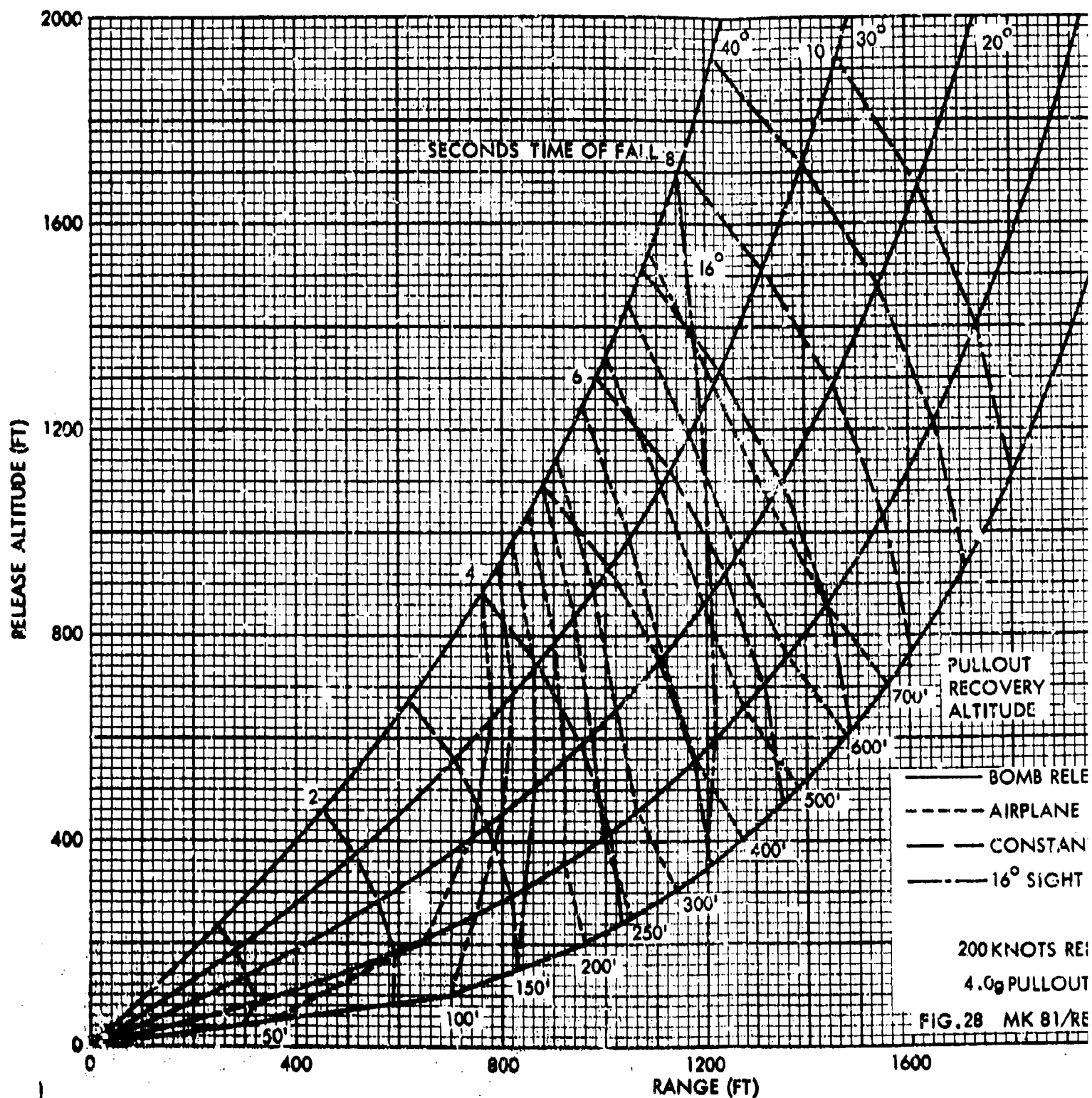




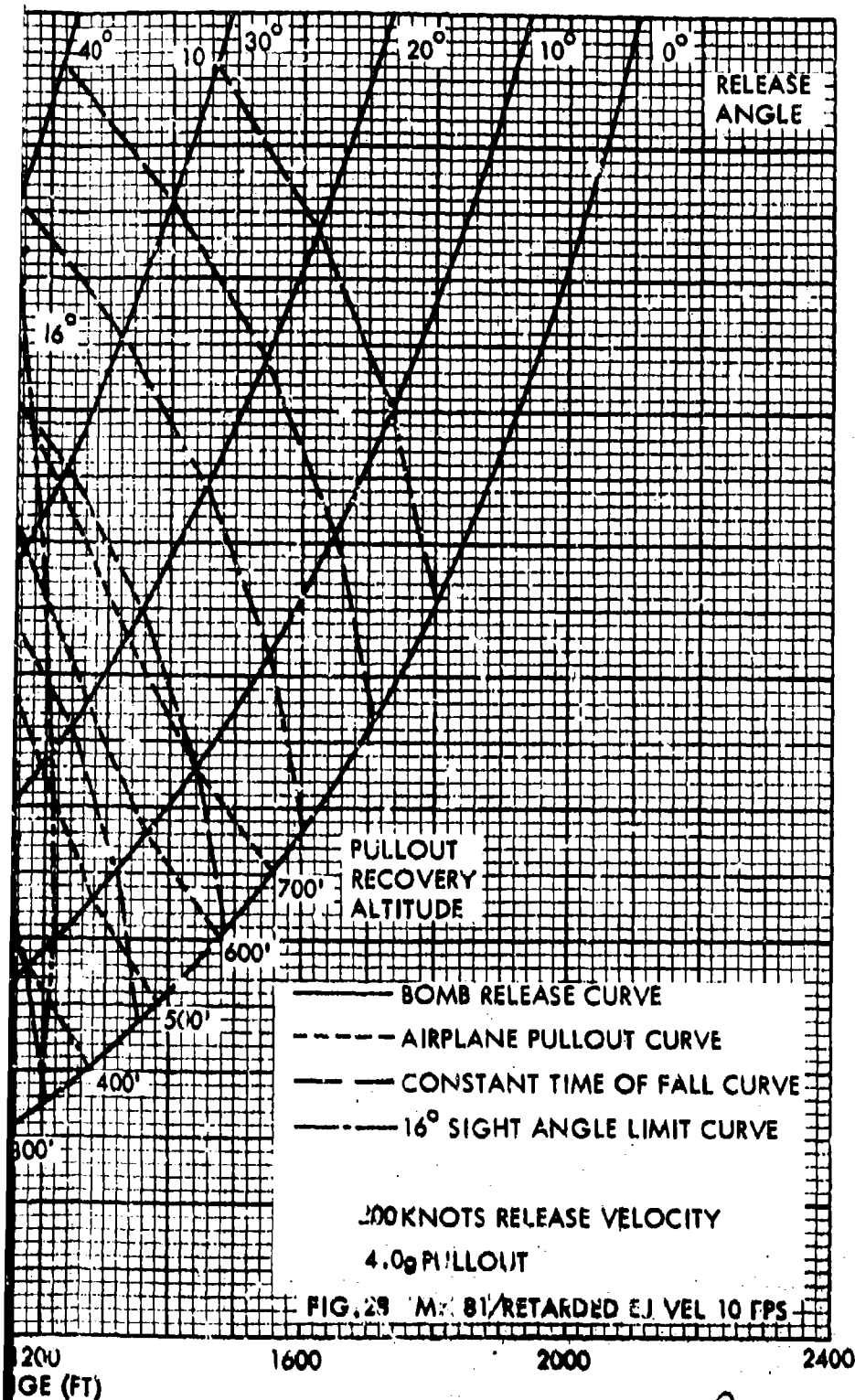




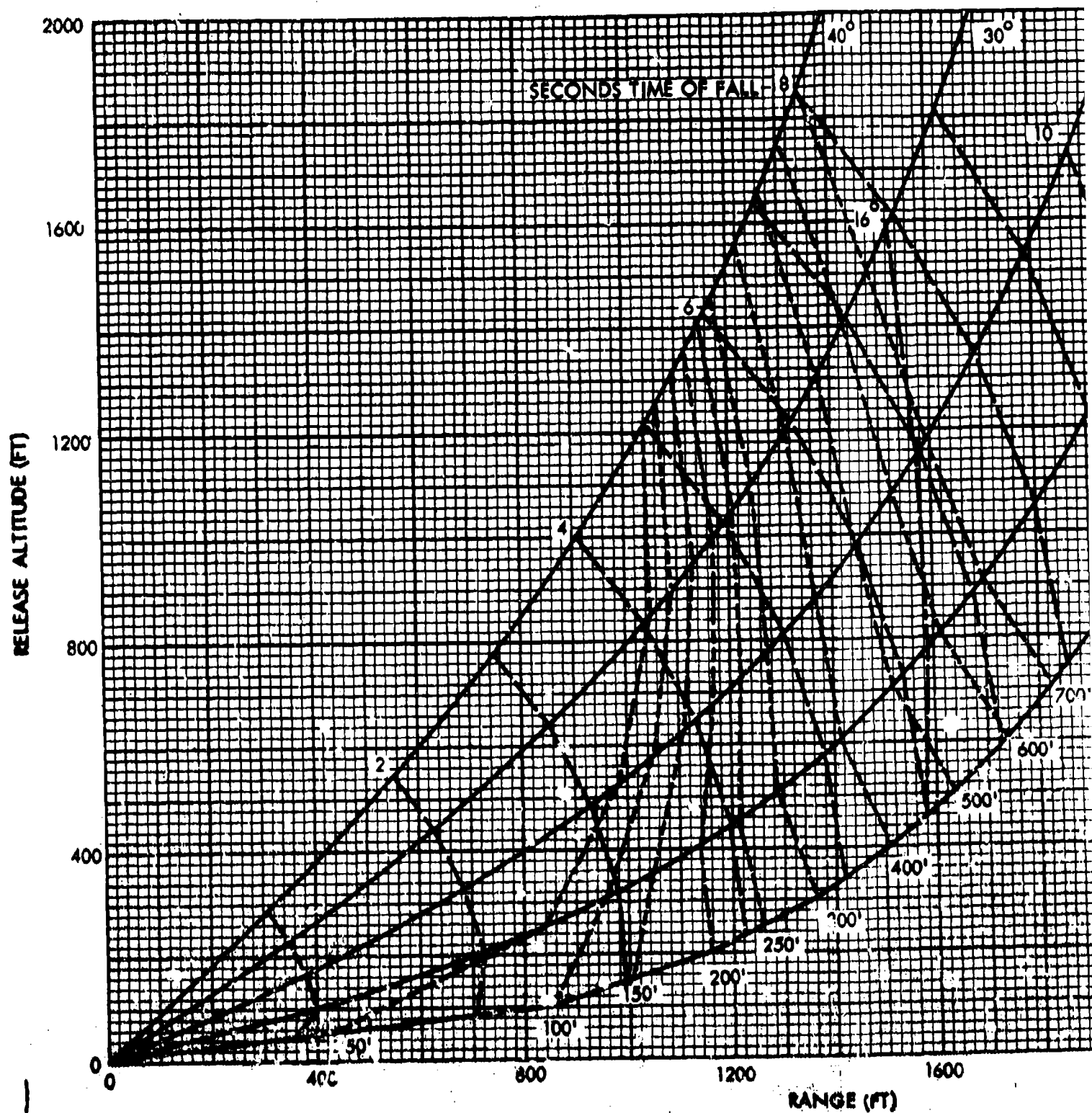




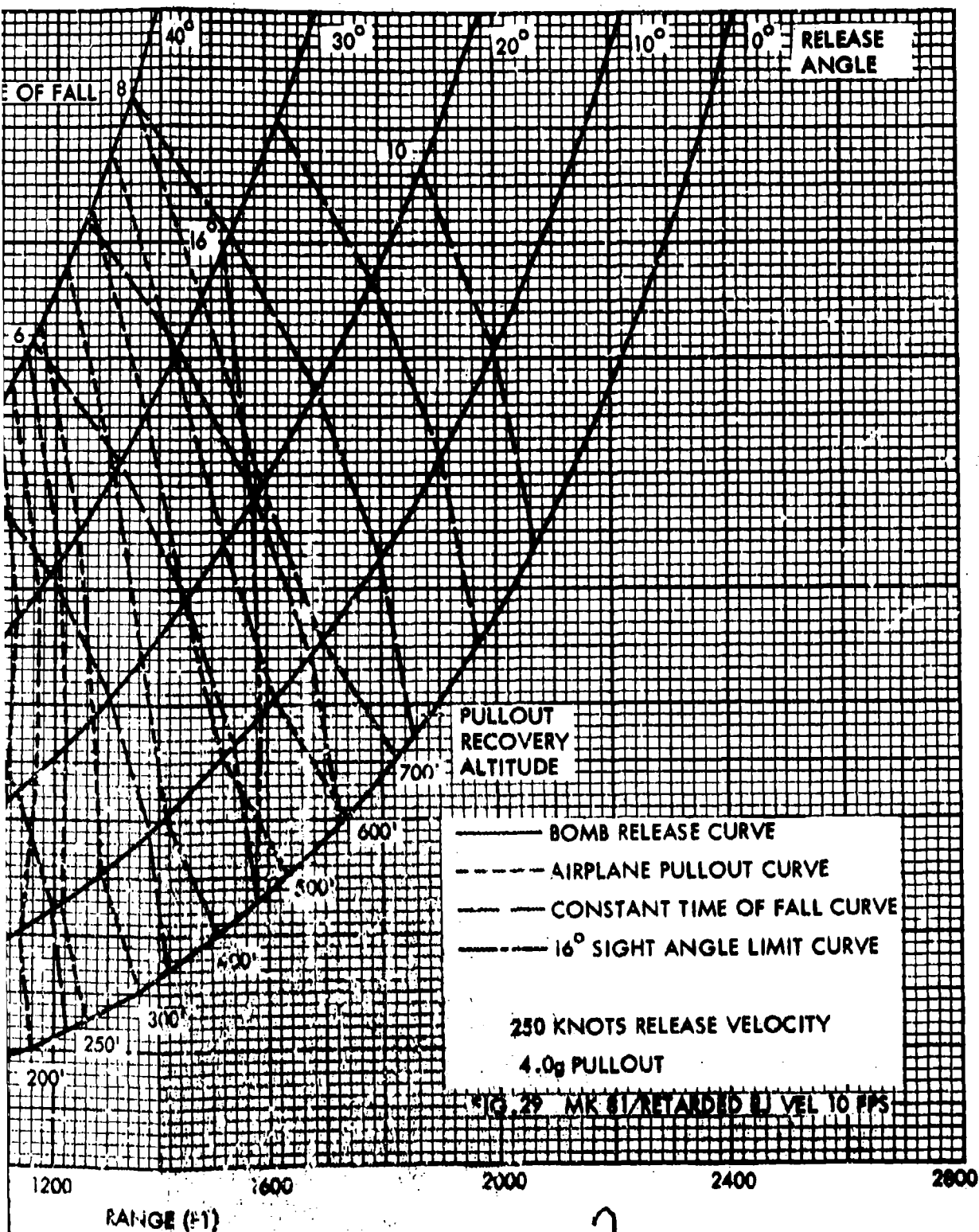
NOLTR 65-230

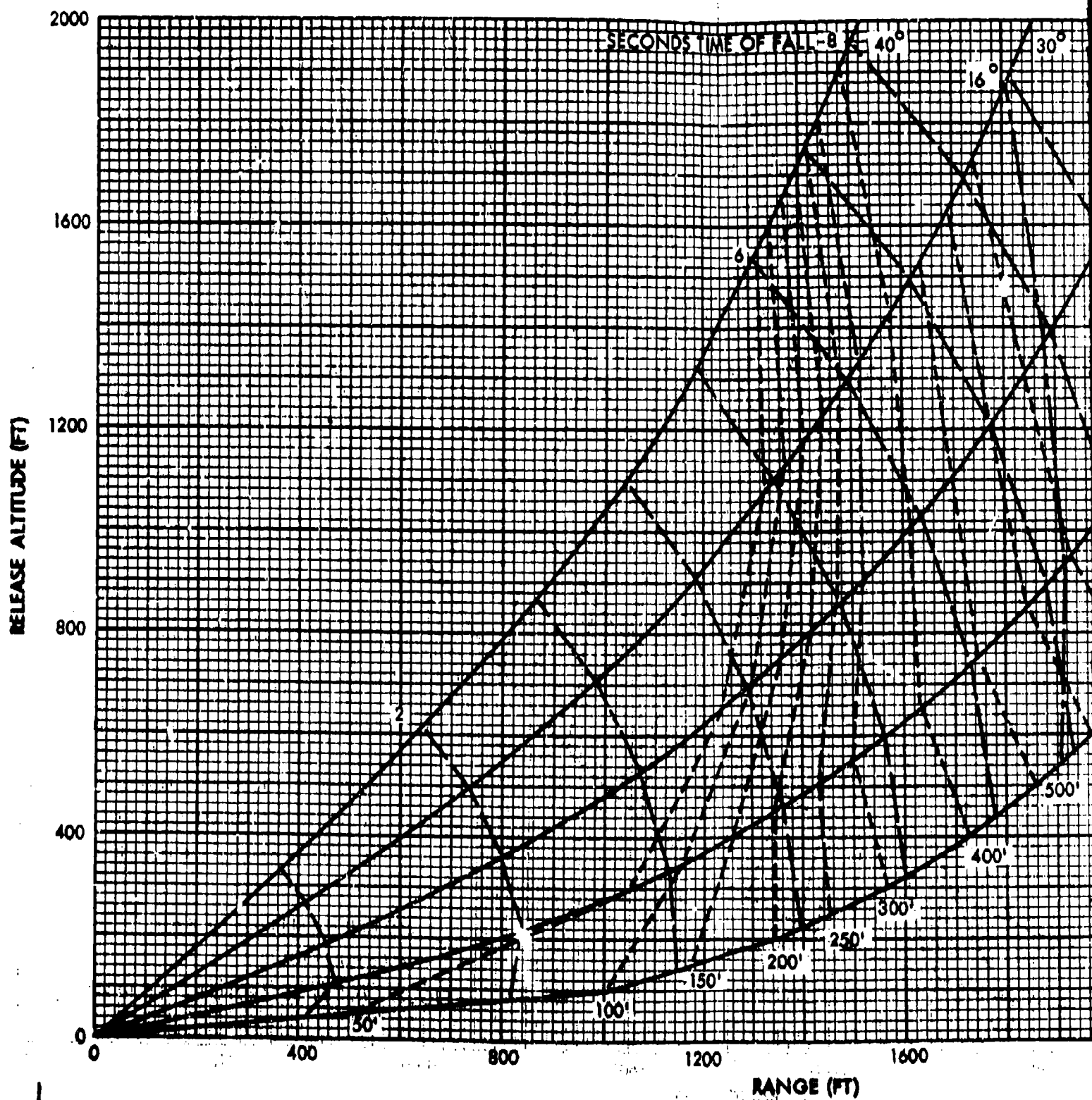


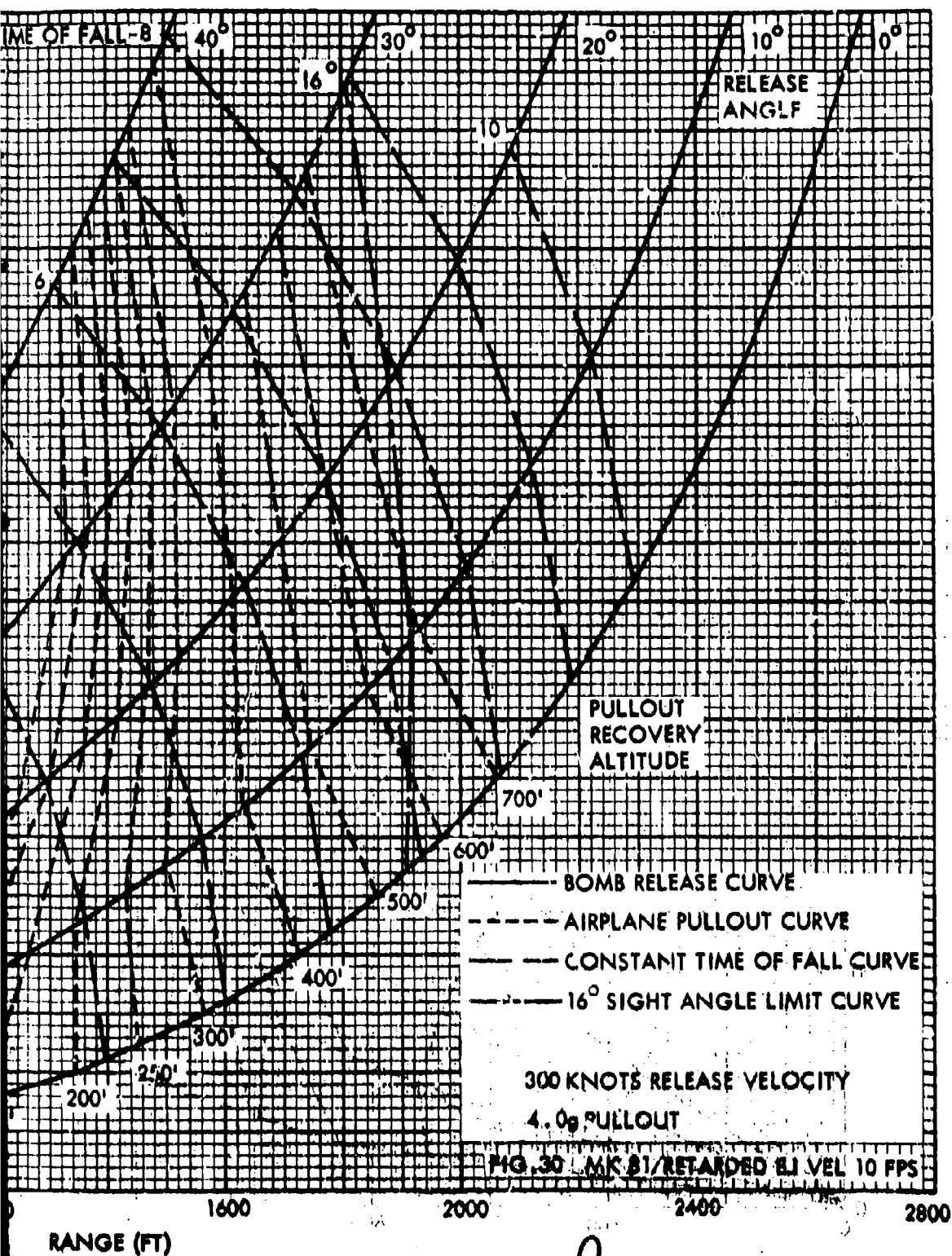
2

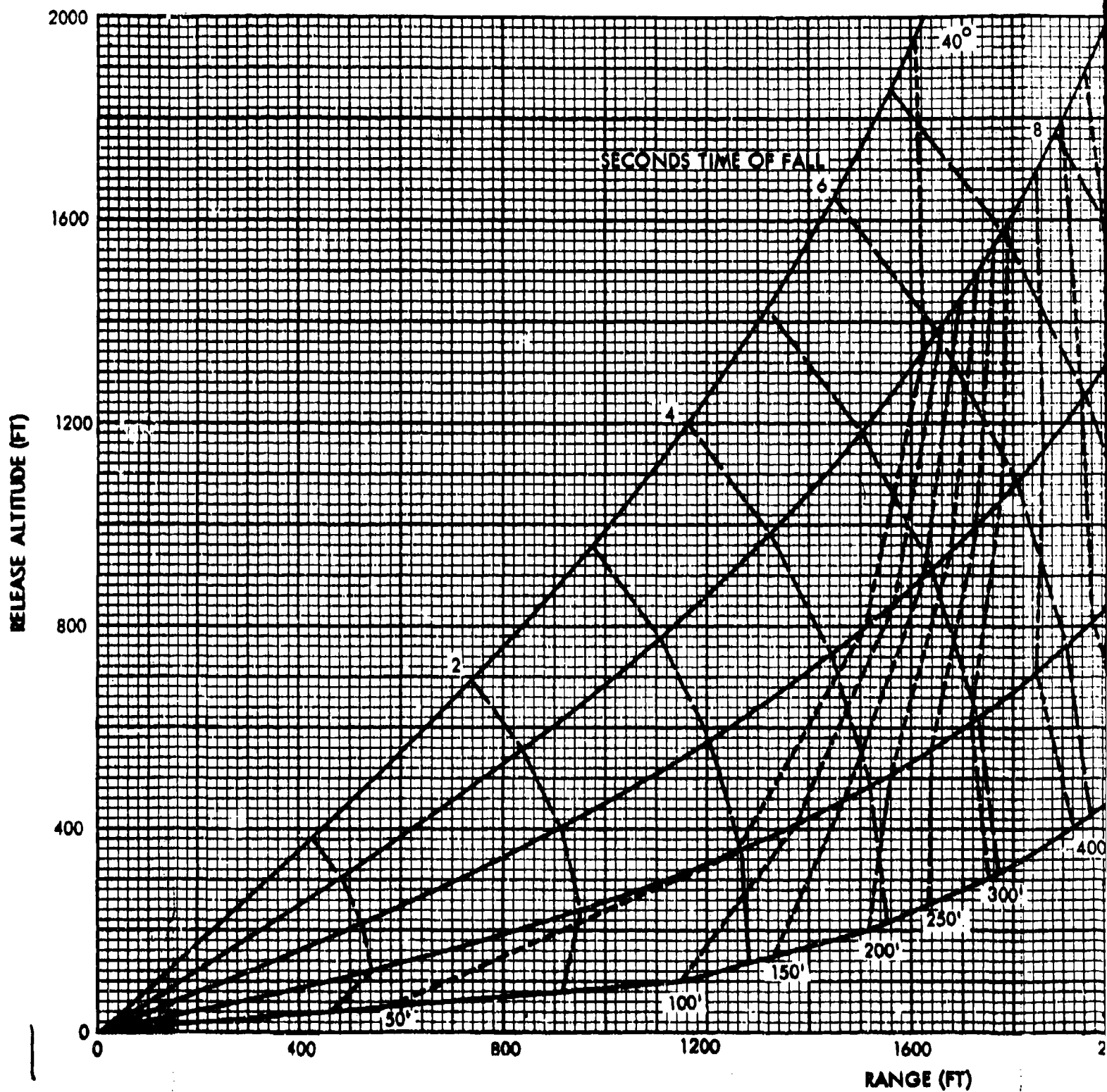


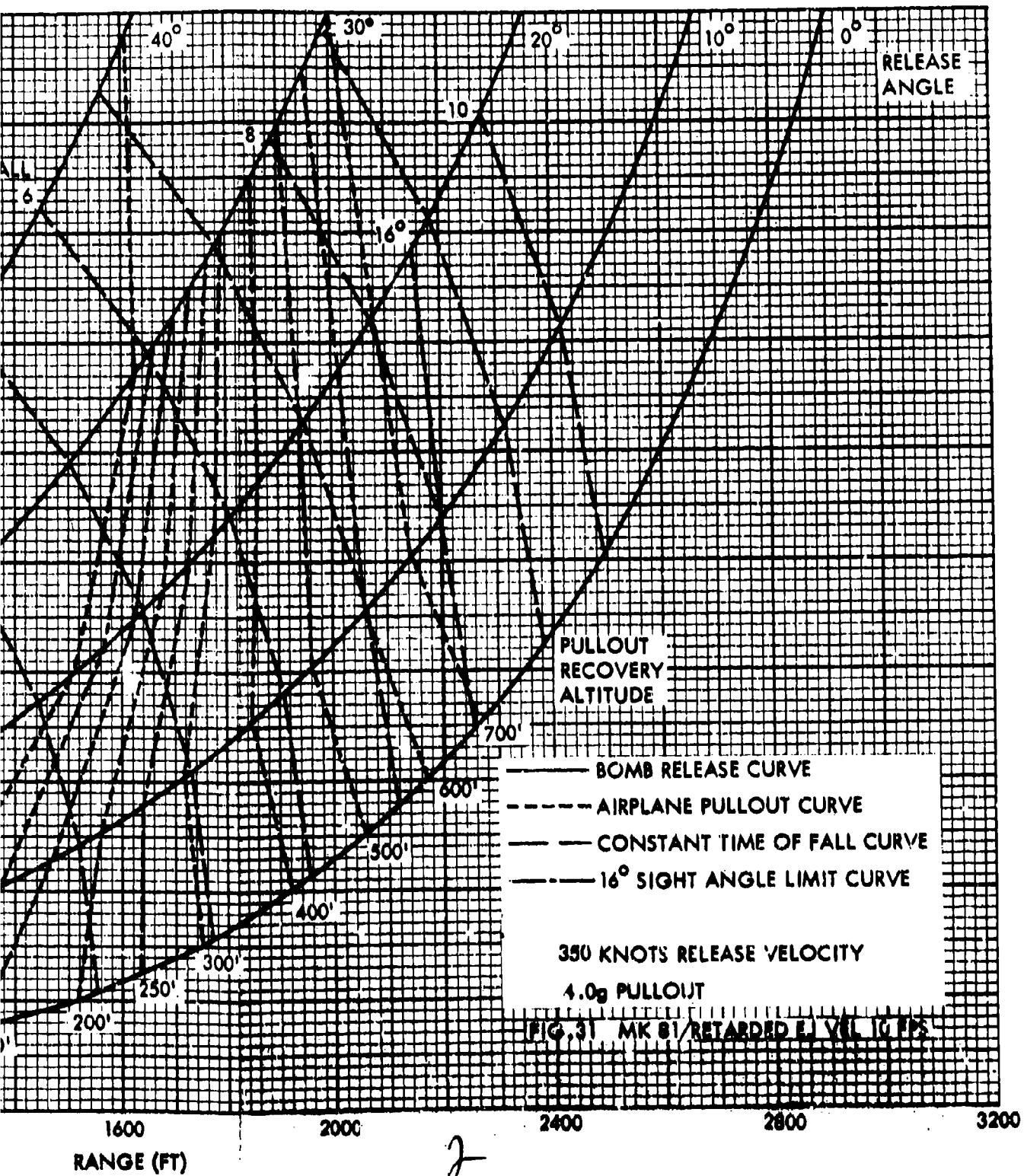
NOLTR 65-230

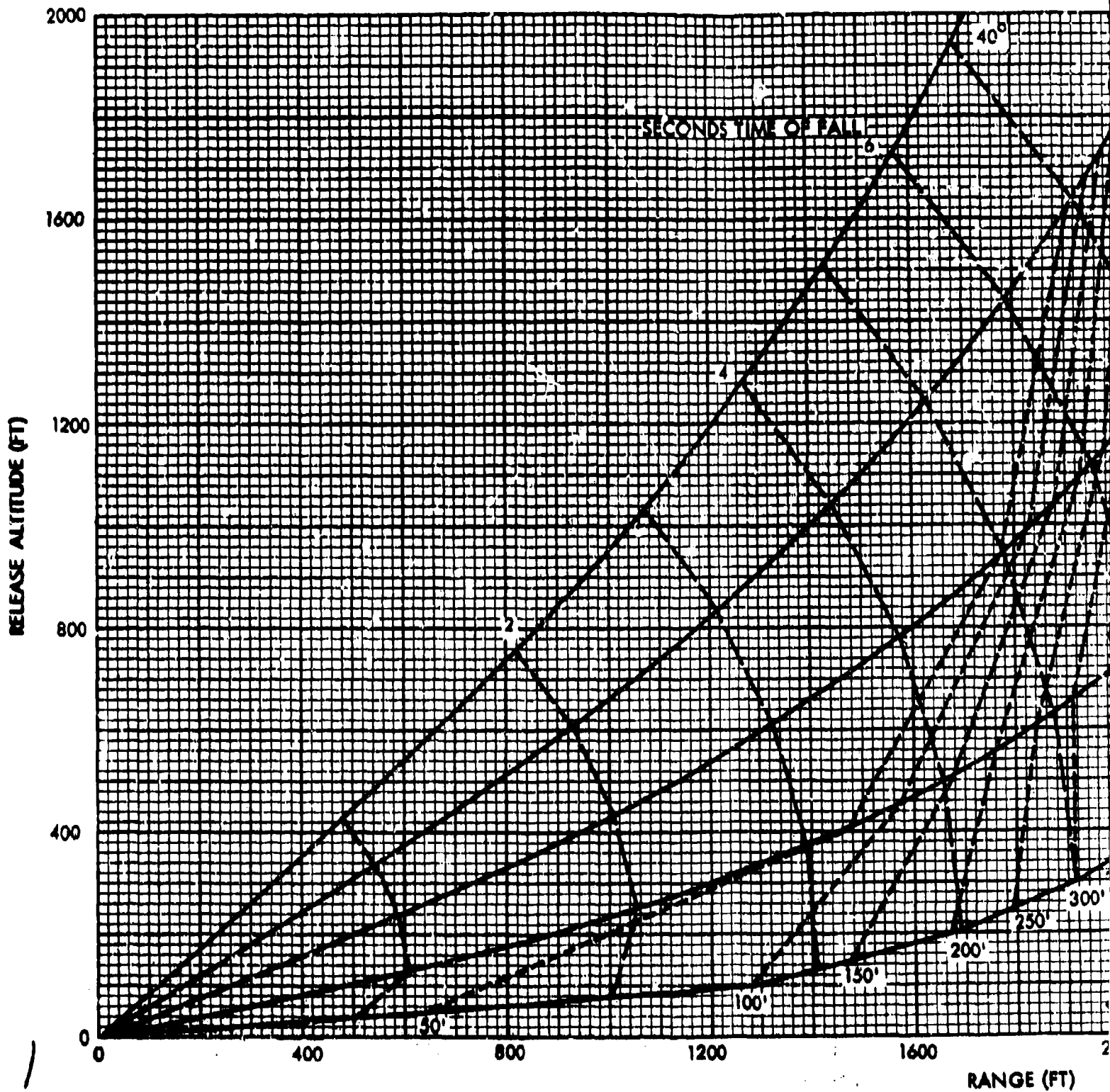




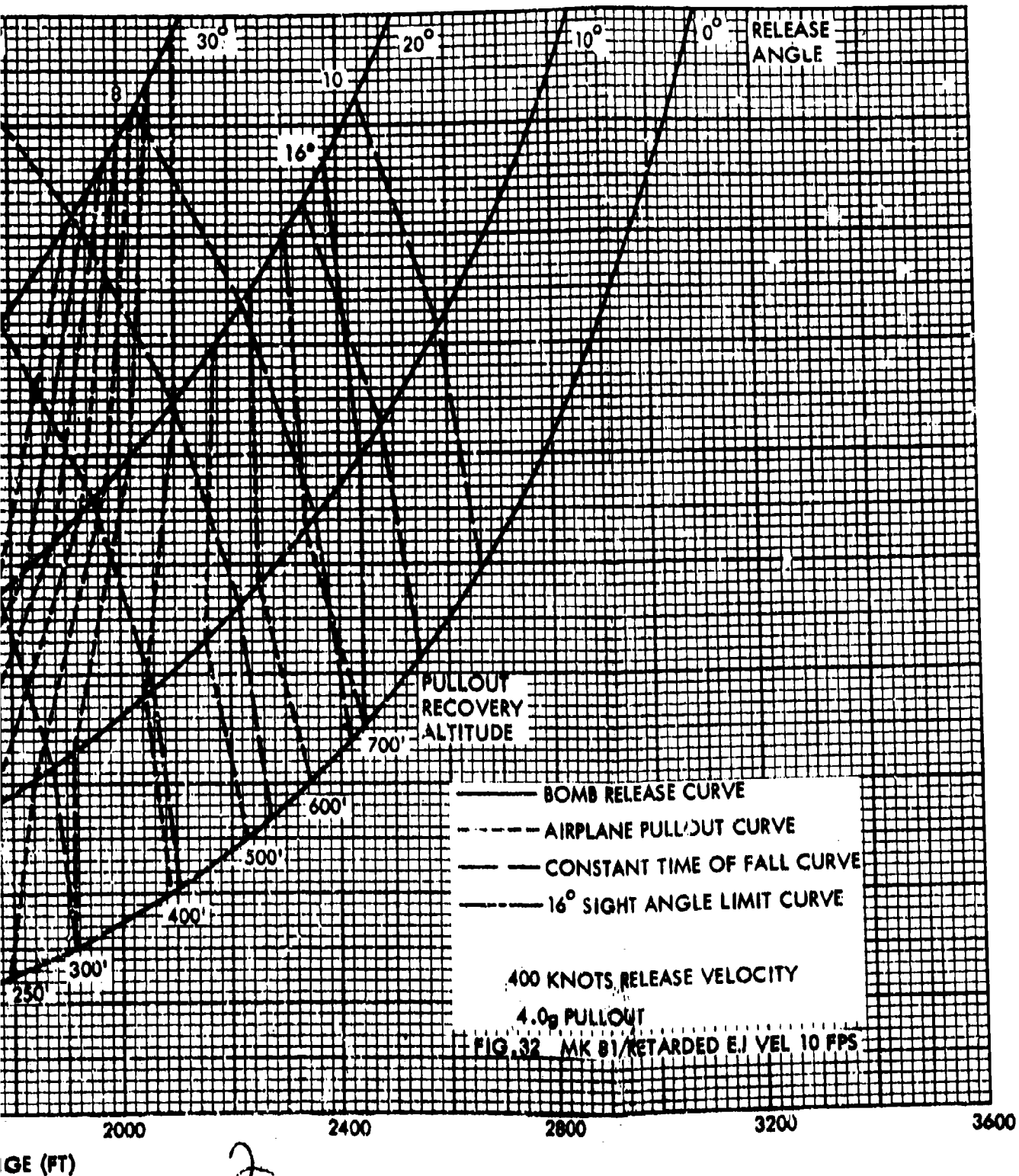


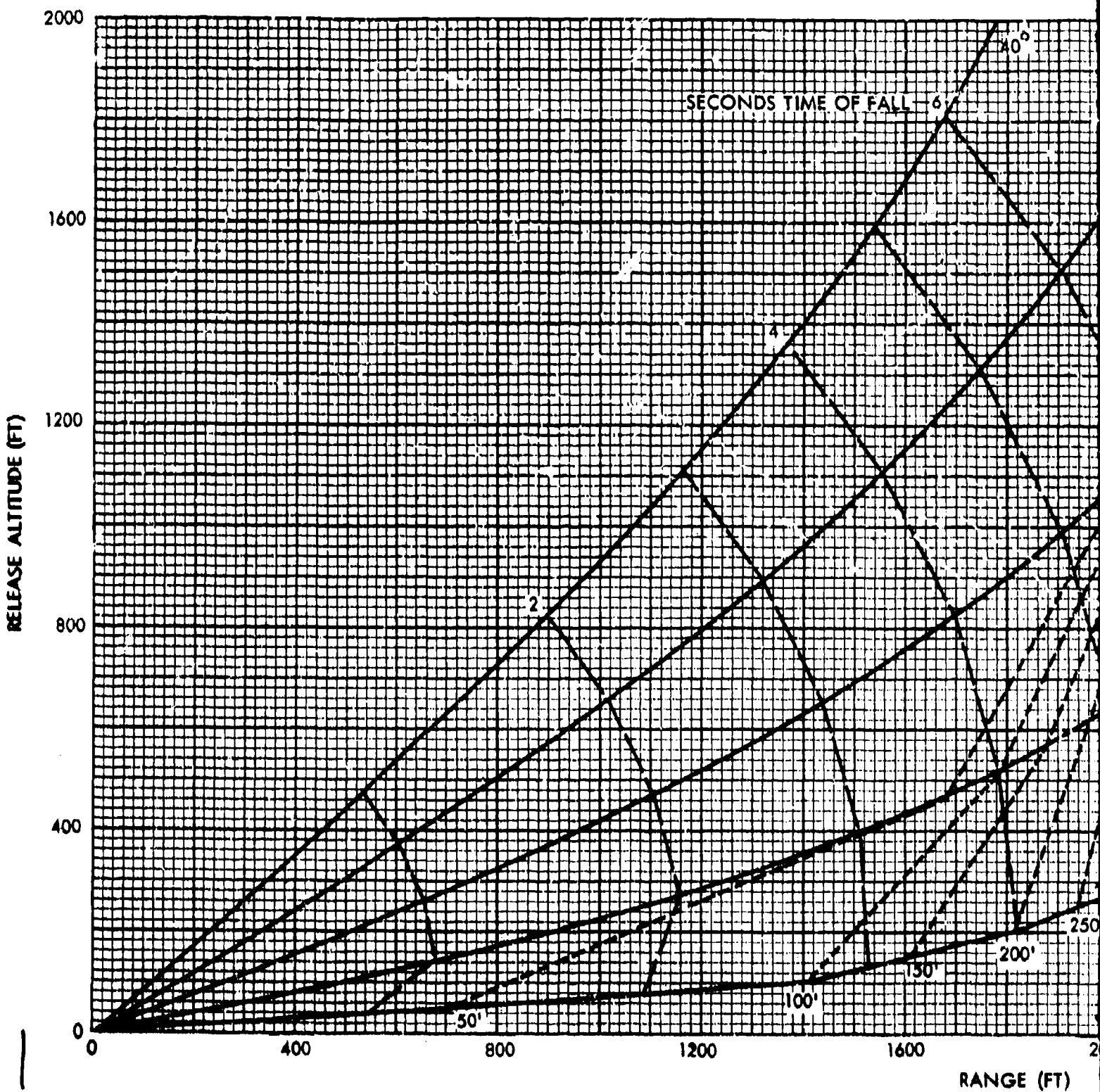


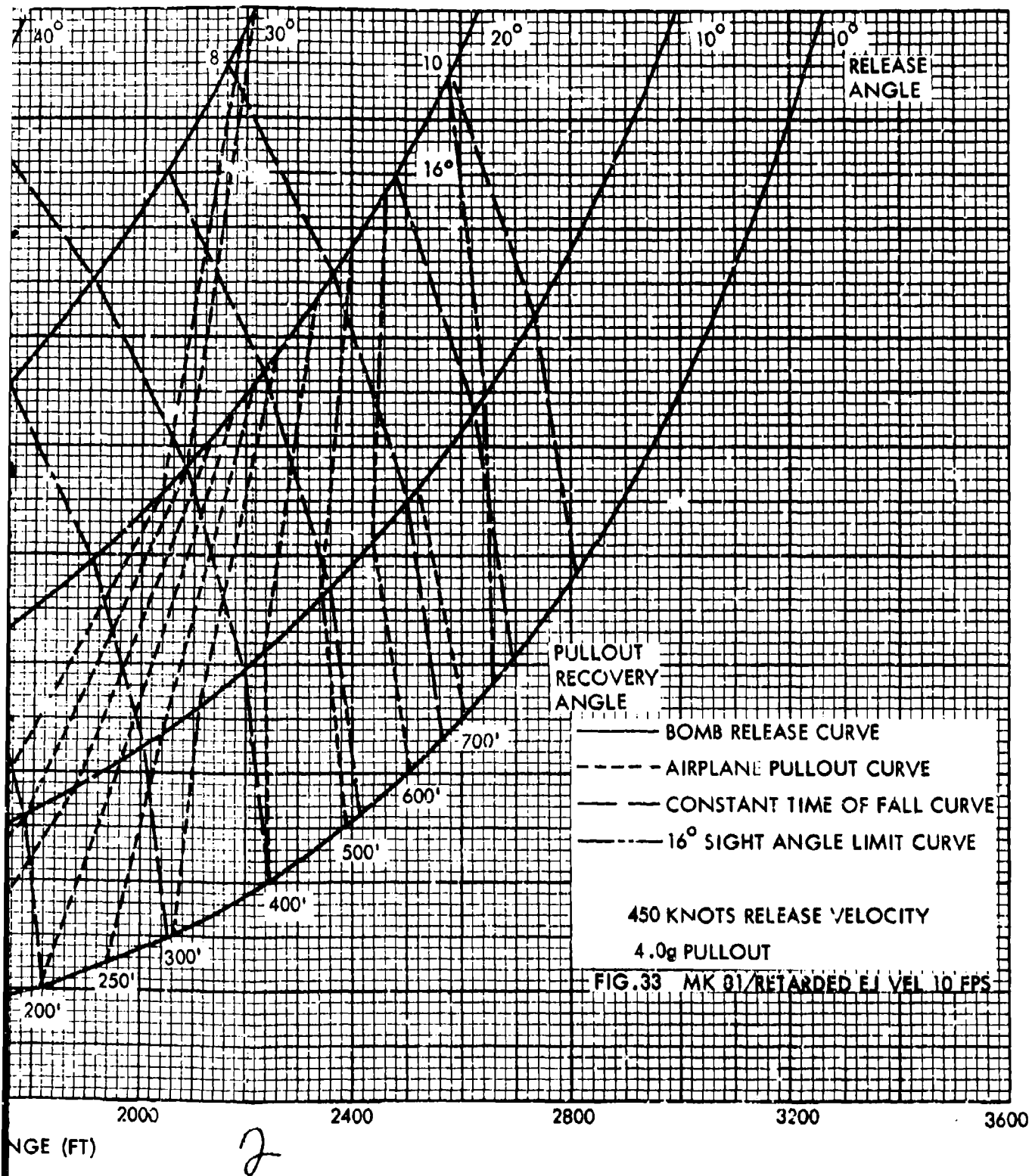


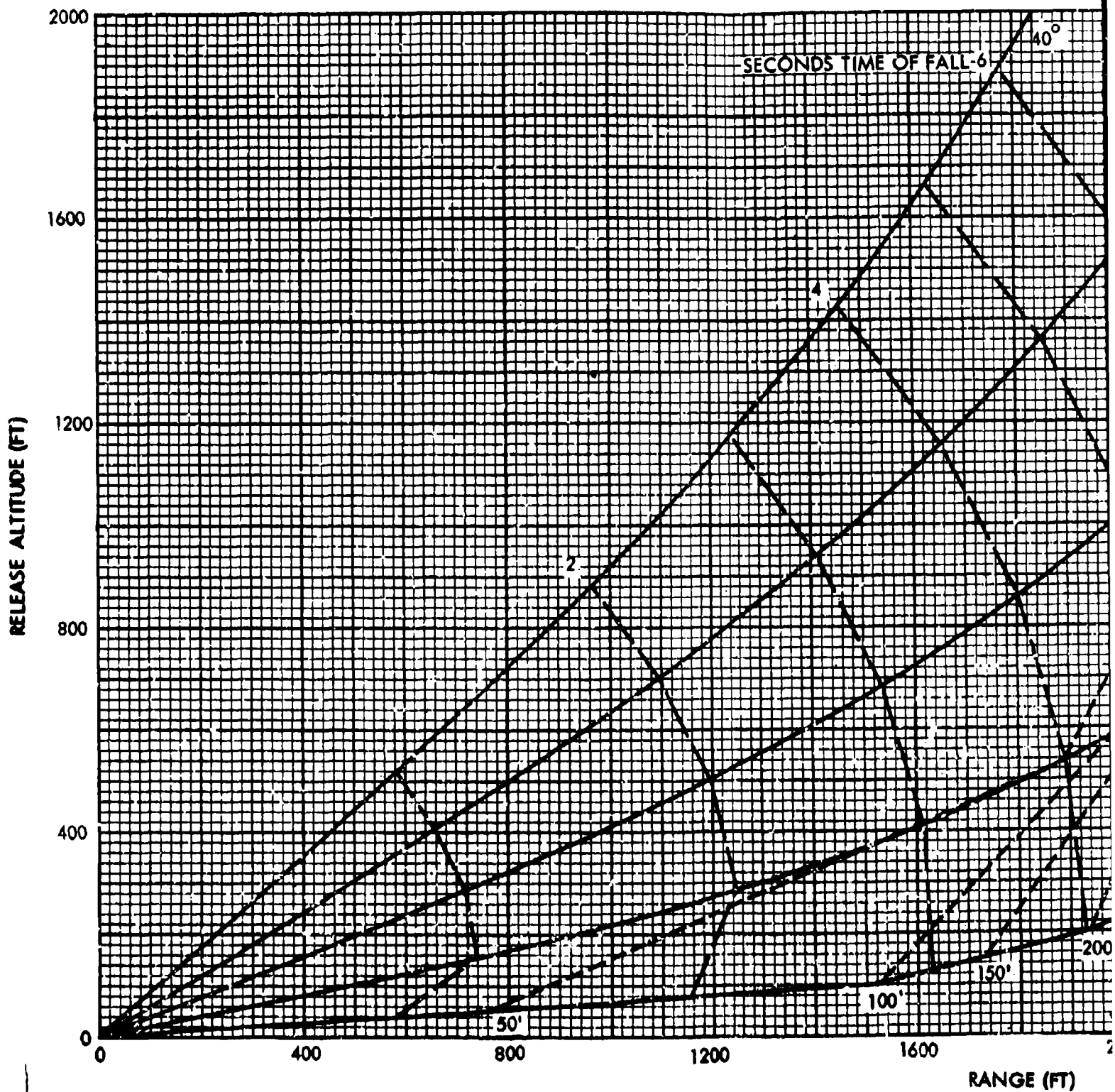


NOLTR 65-230

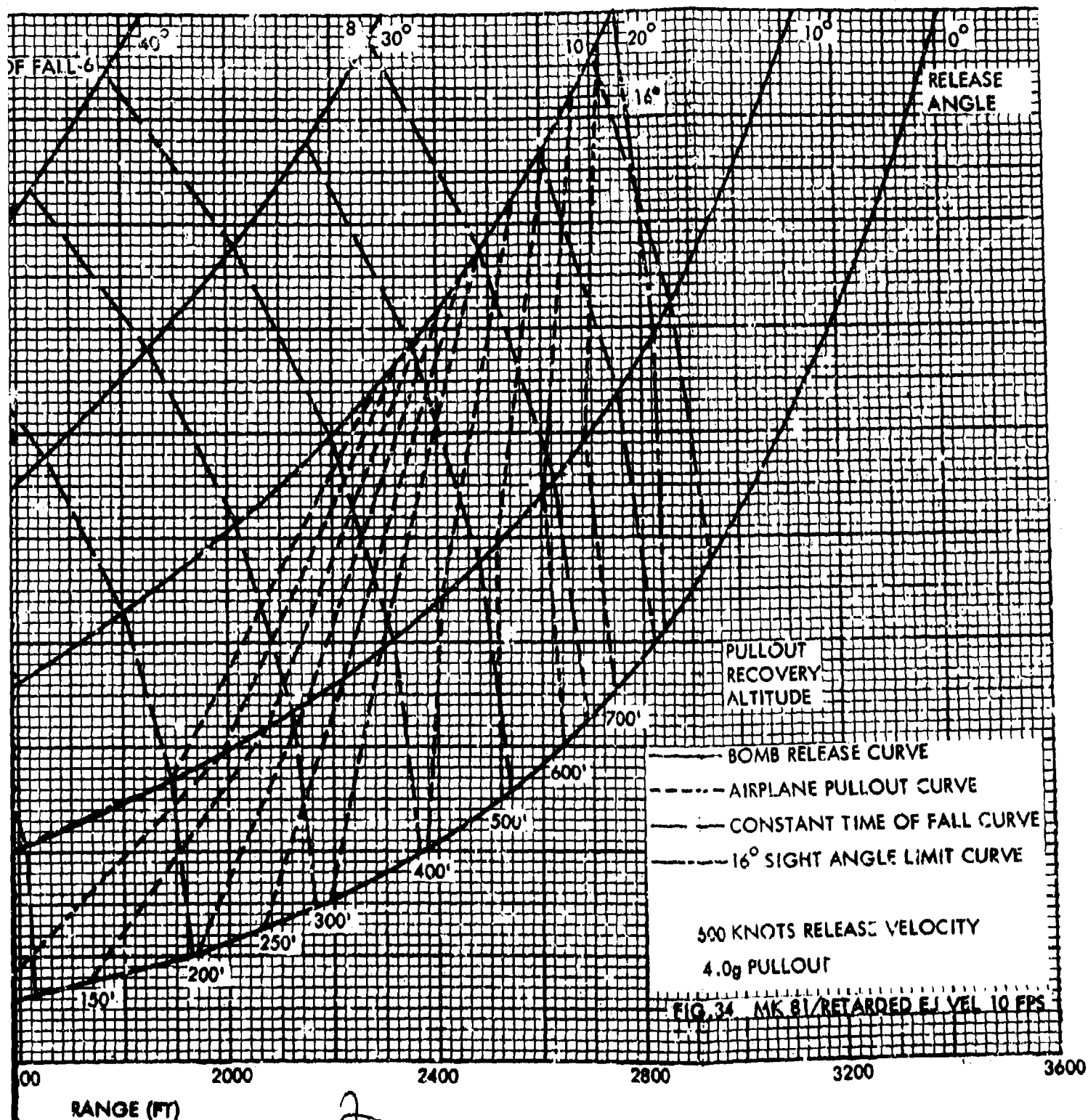


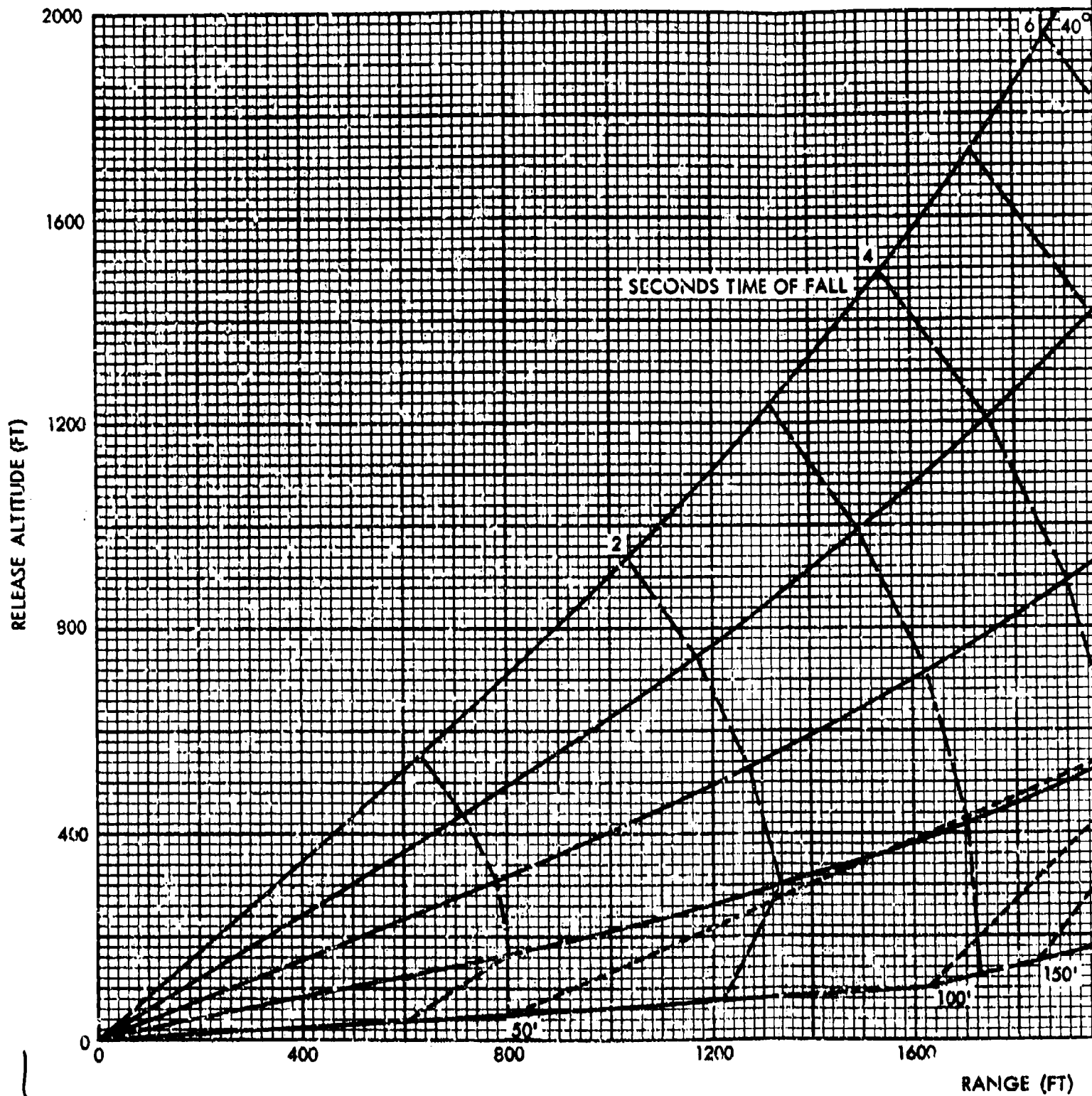






NOLTR 65-230





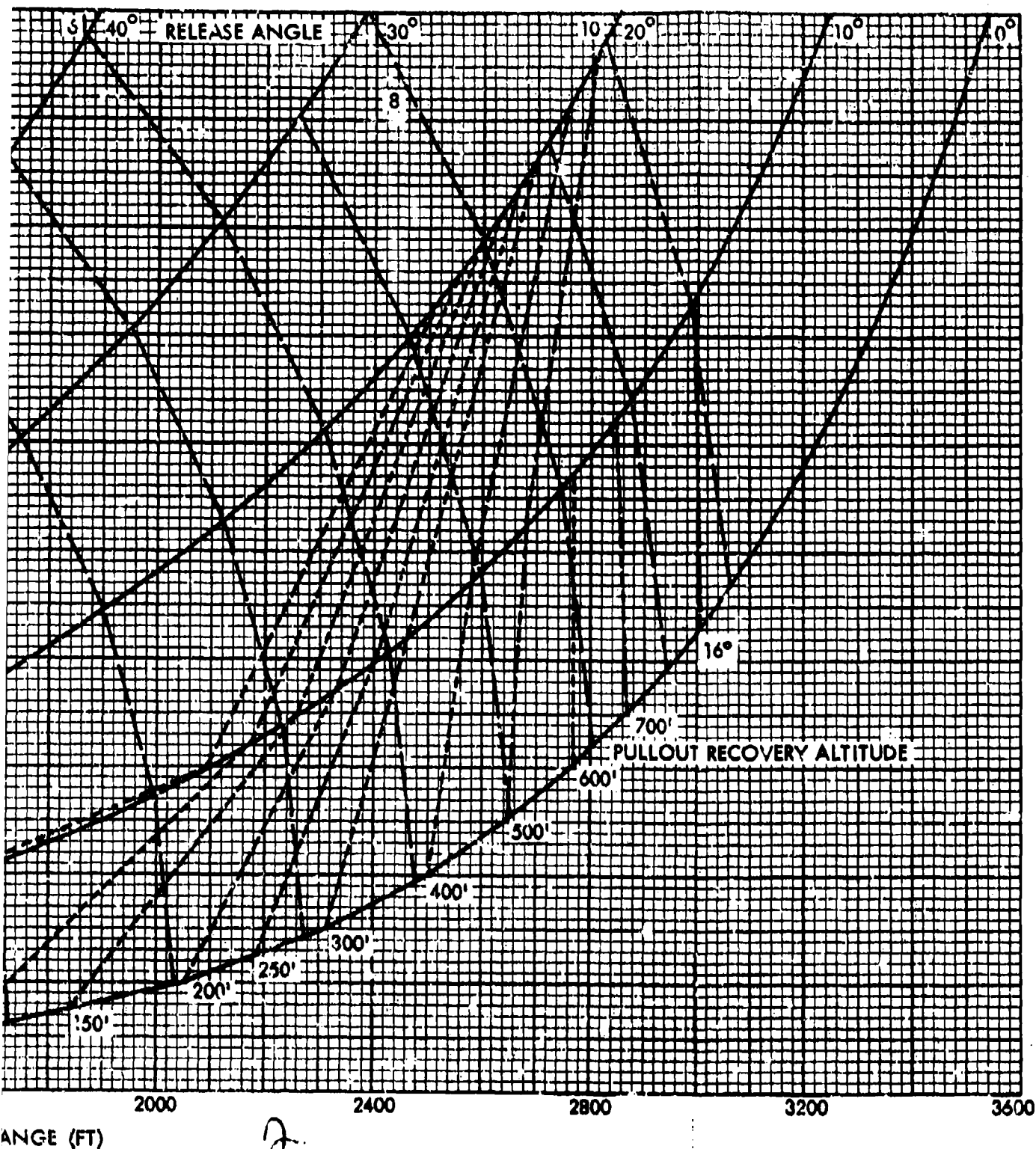
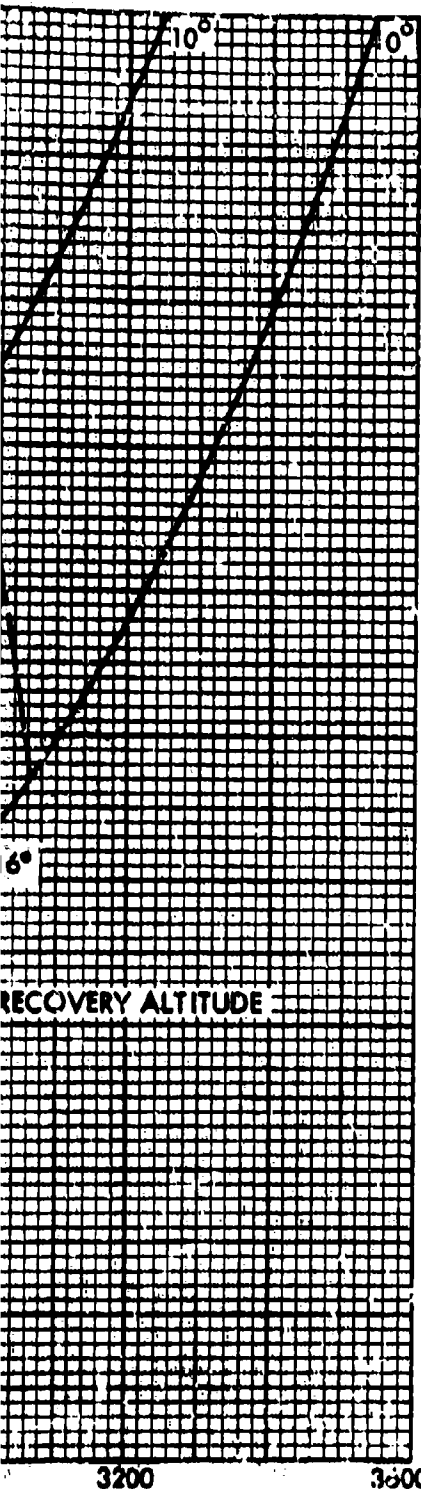


FIG.35 MK 81/

NOLTR 65-230



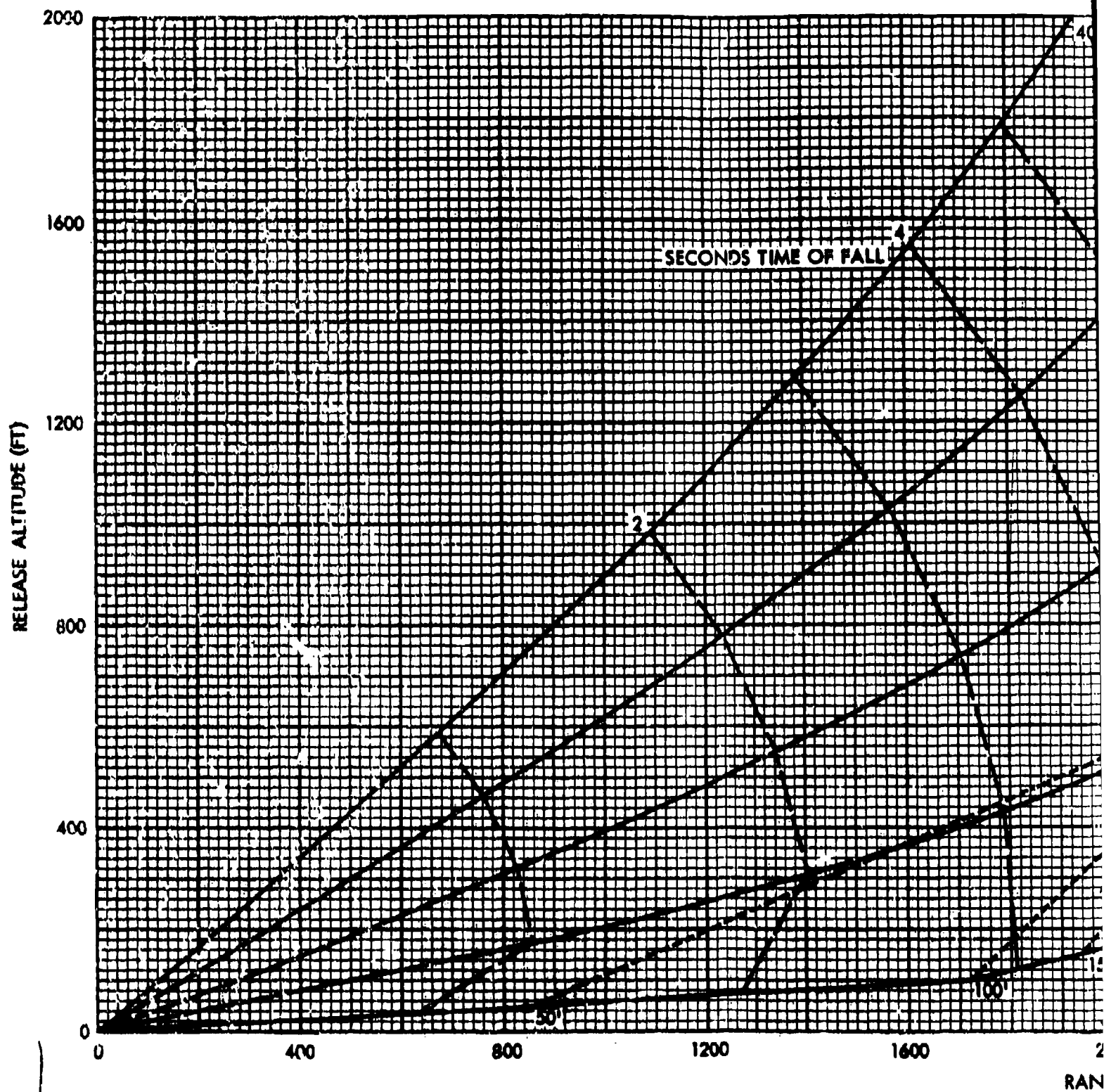
- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

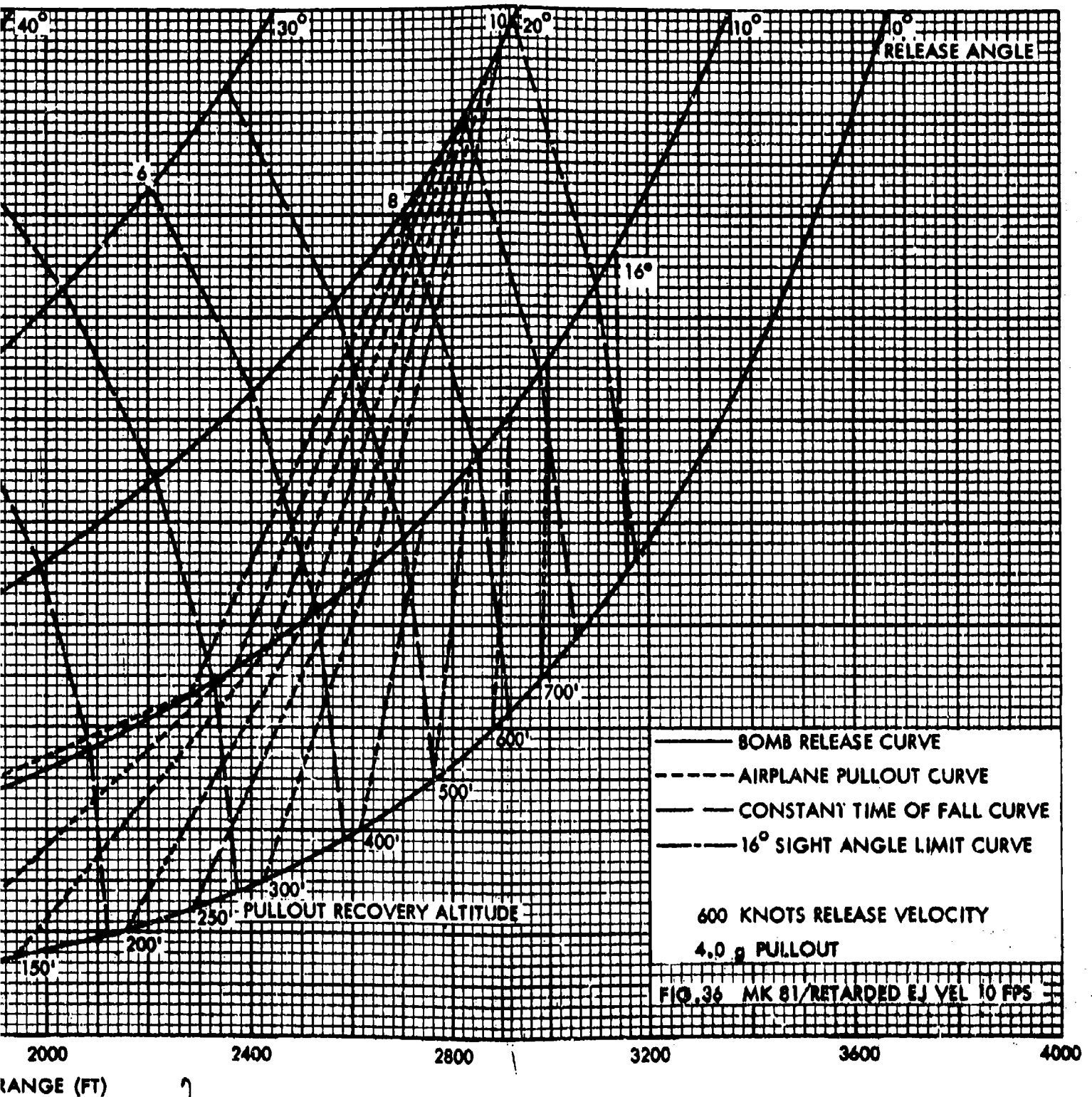
550 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

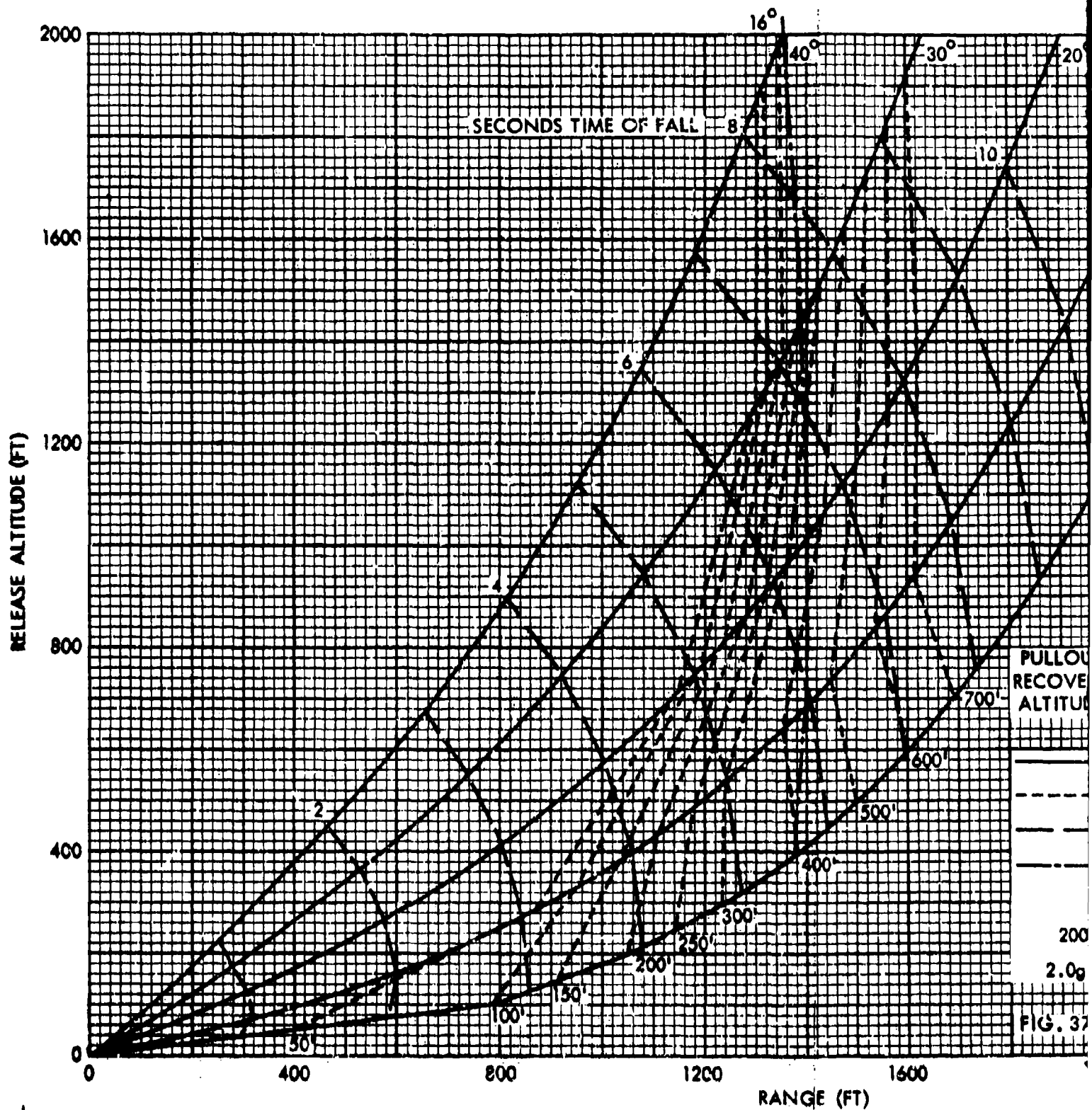
FIG.35 MK 81/RETARDED EJ VEL 10 FPS

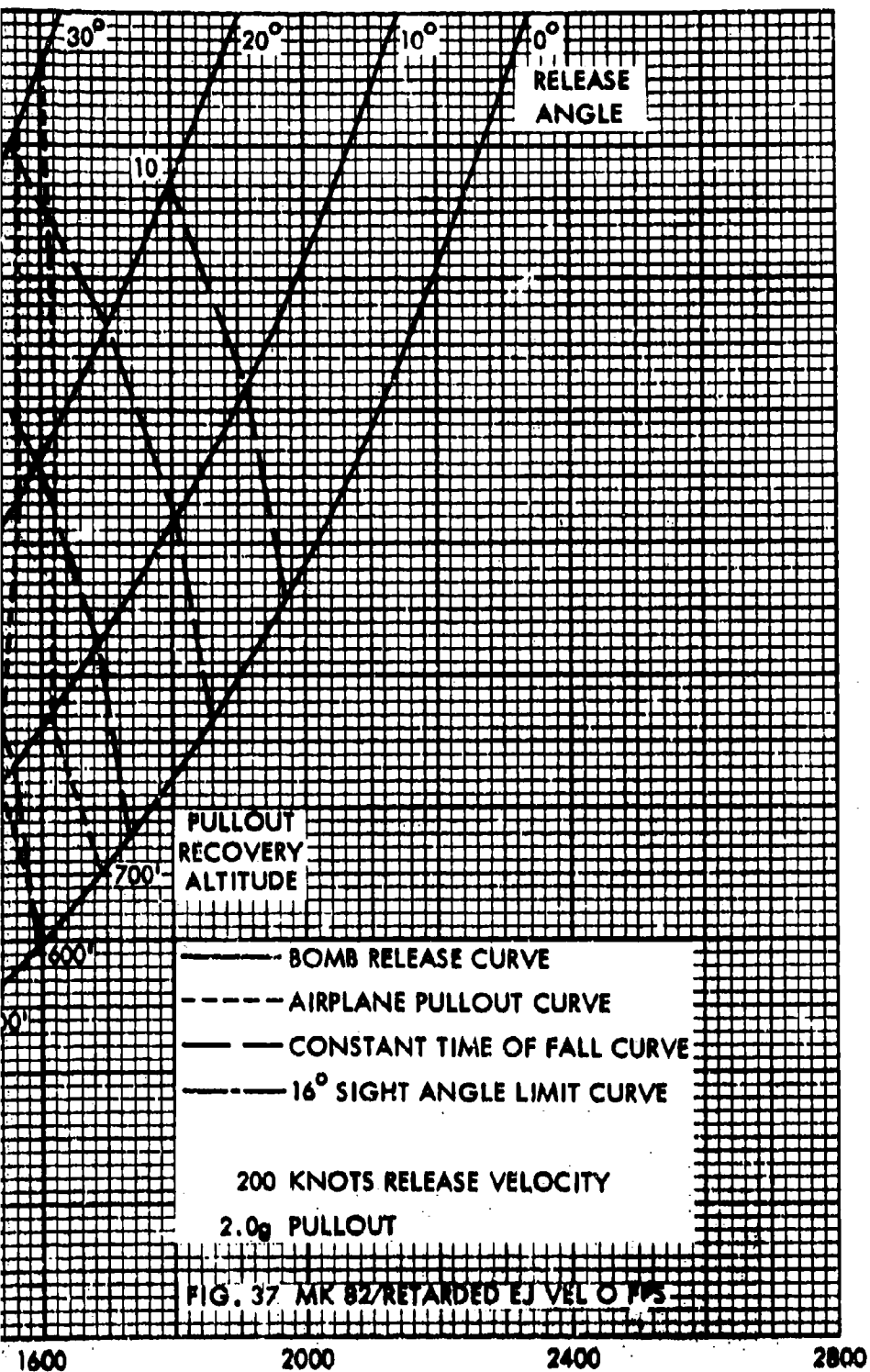
3



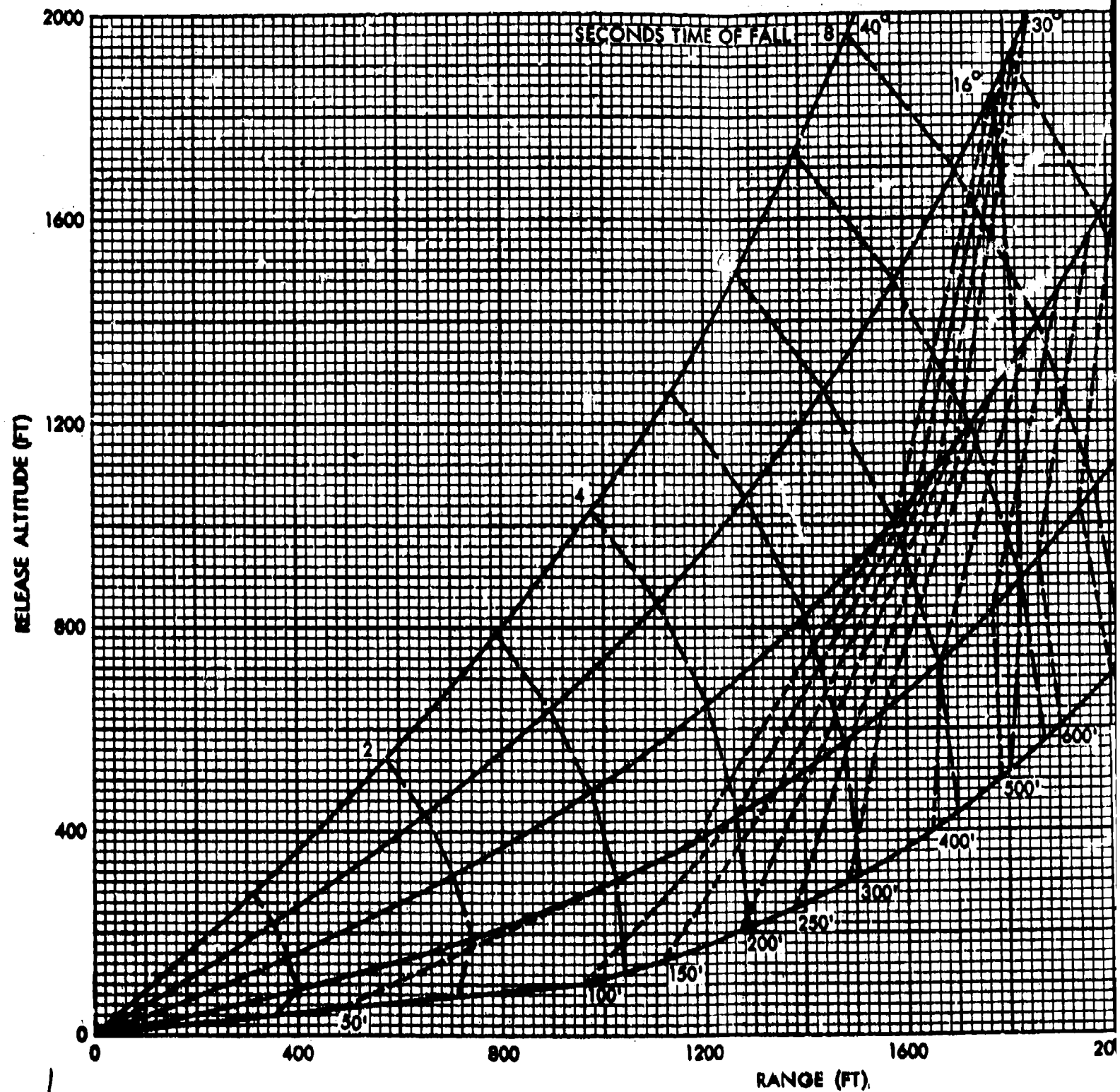


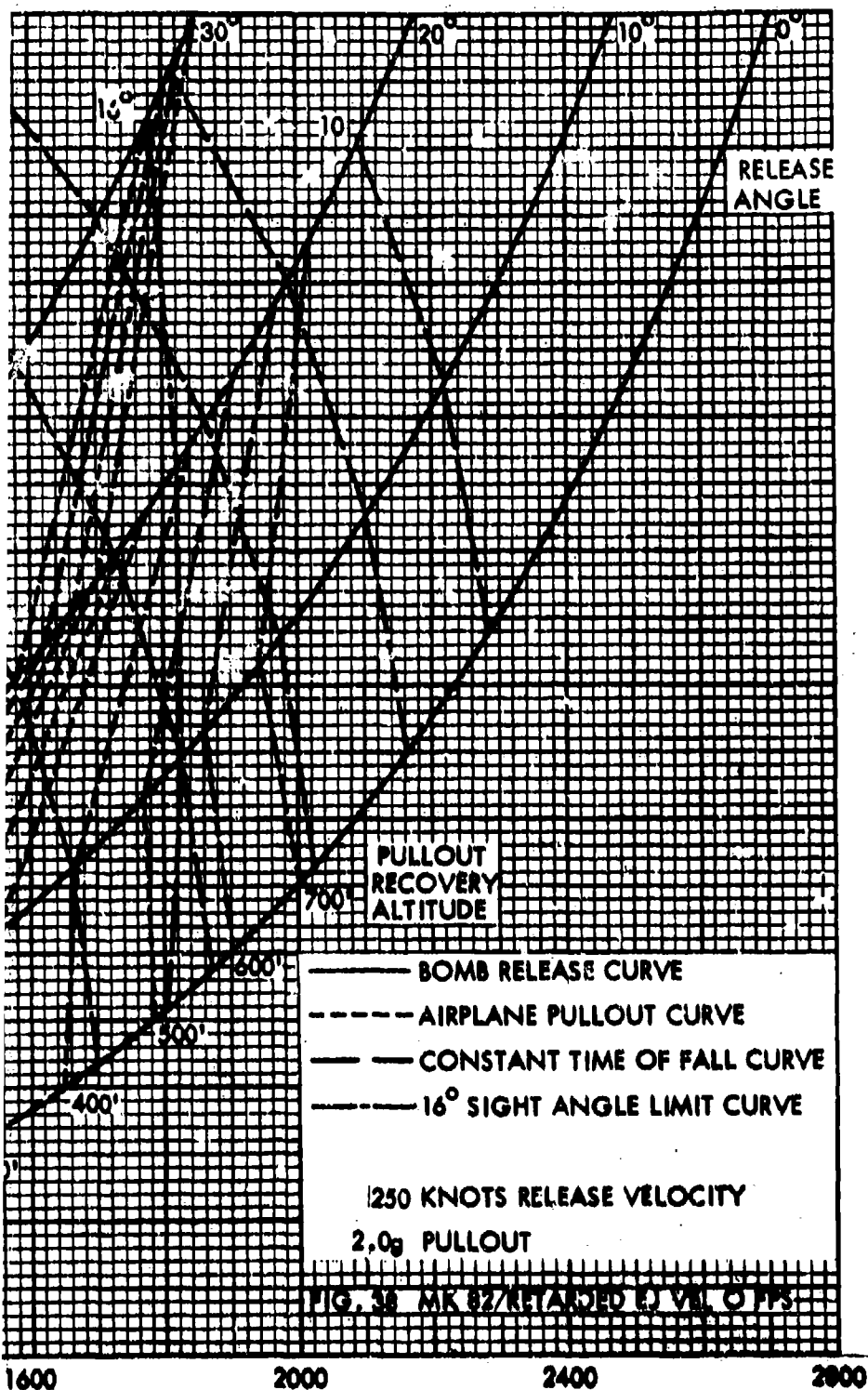
2



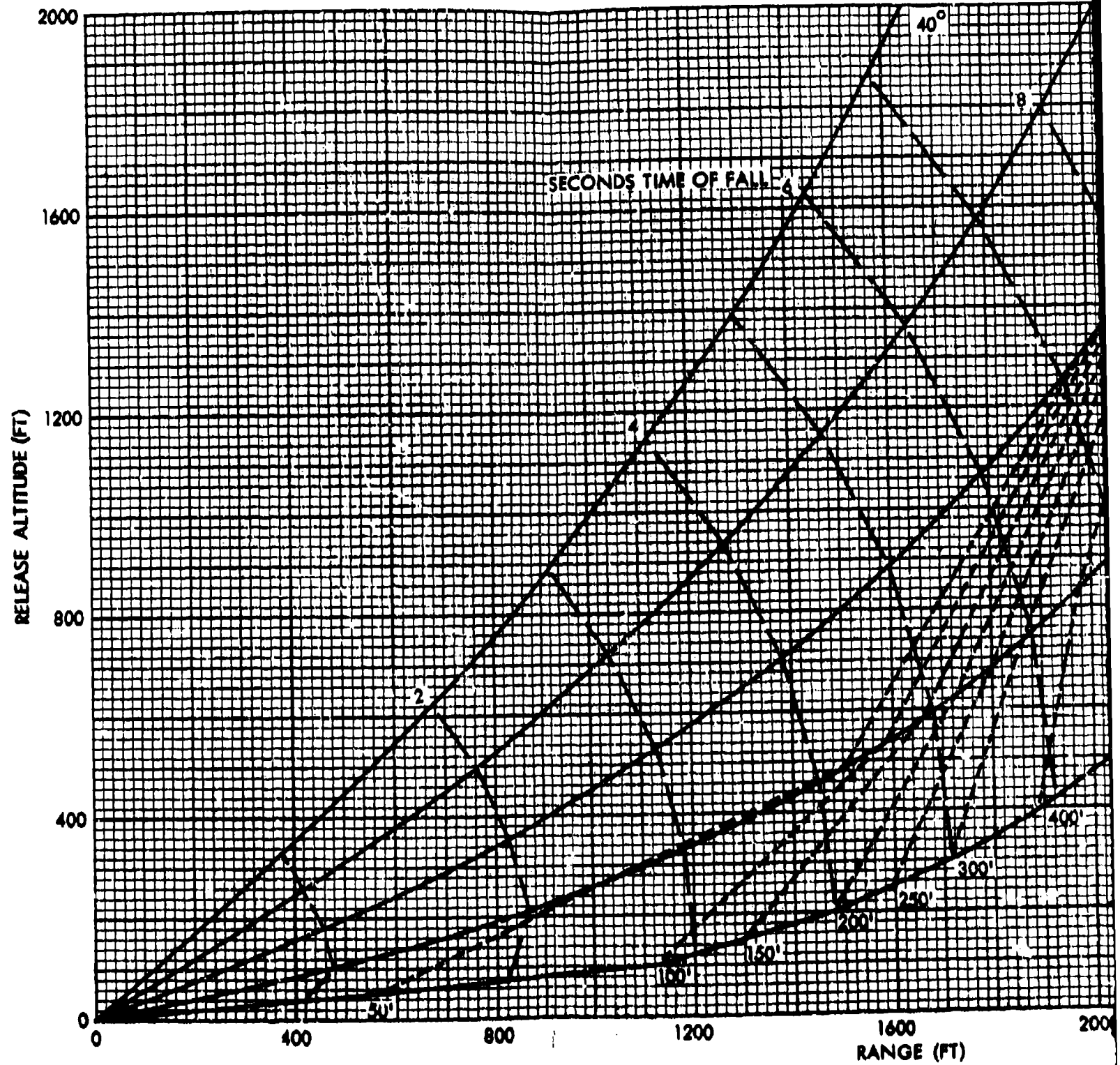


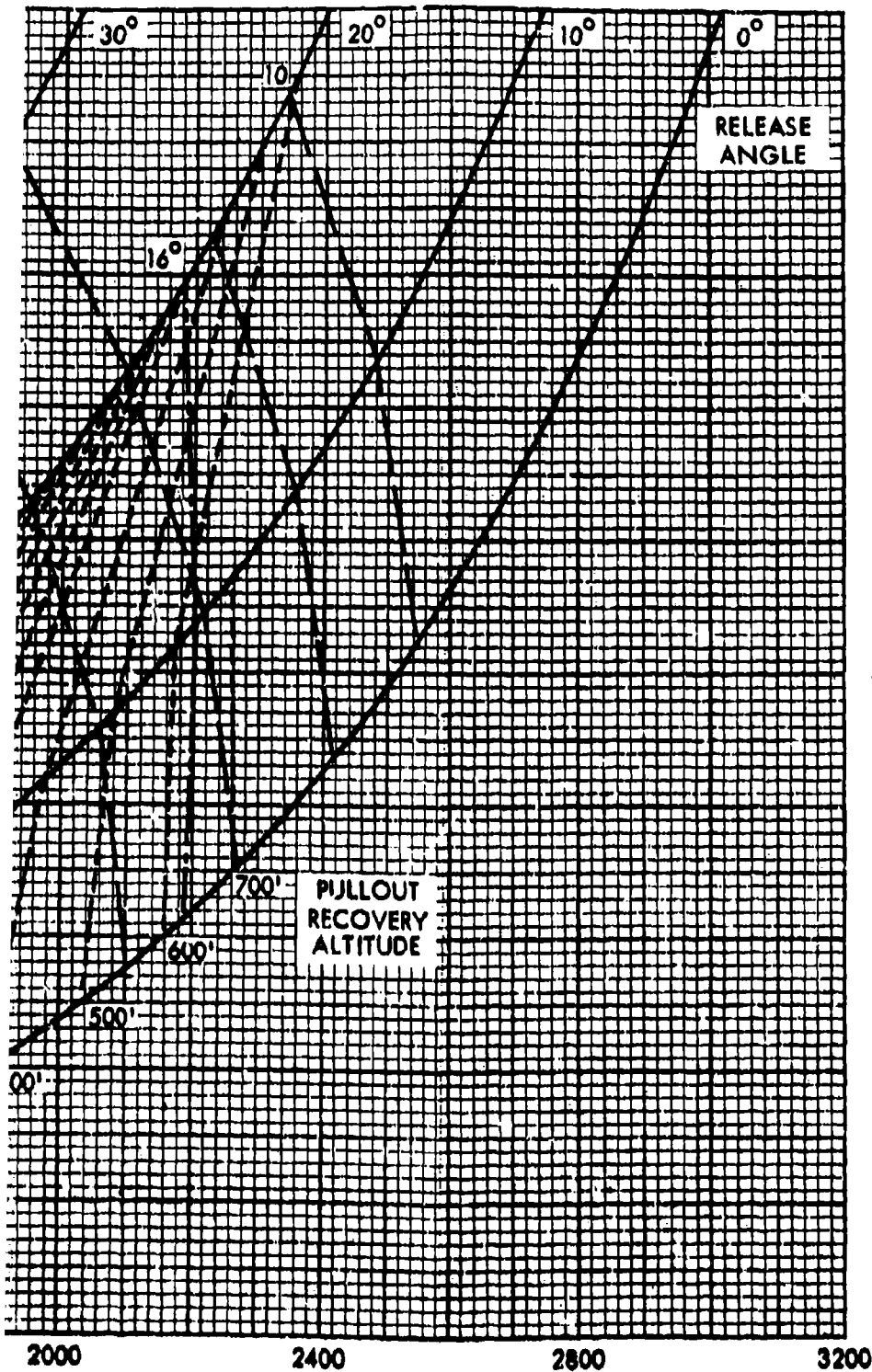
2





2

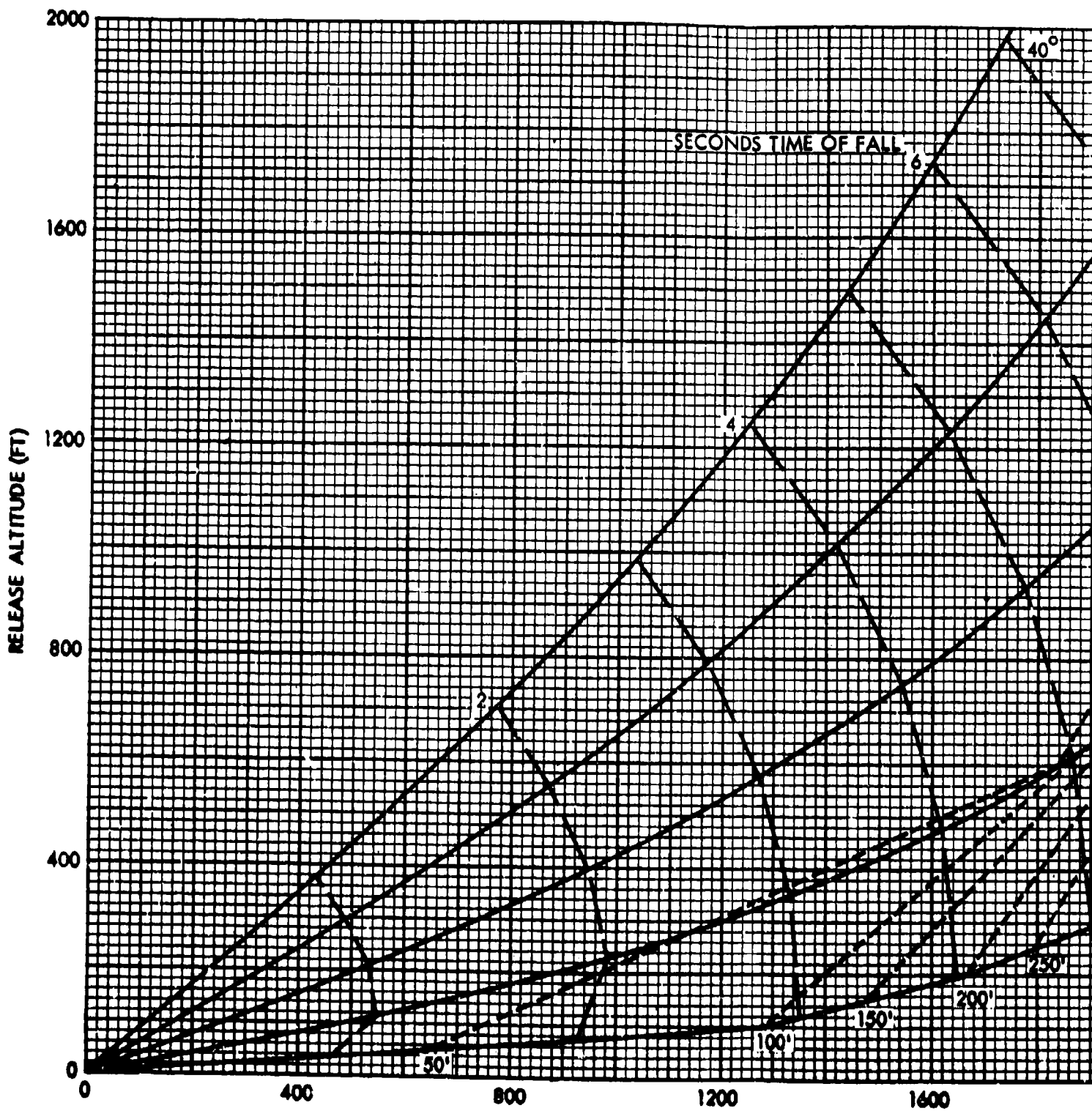


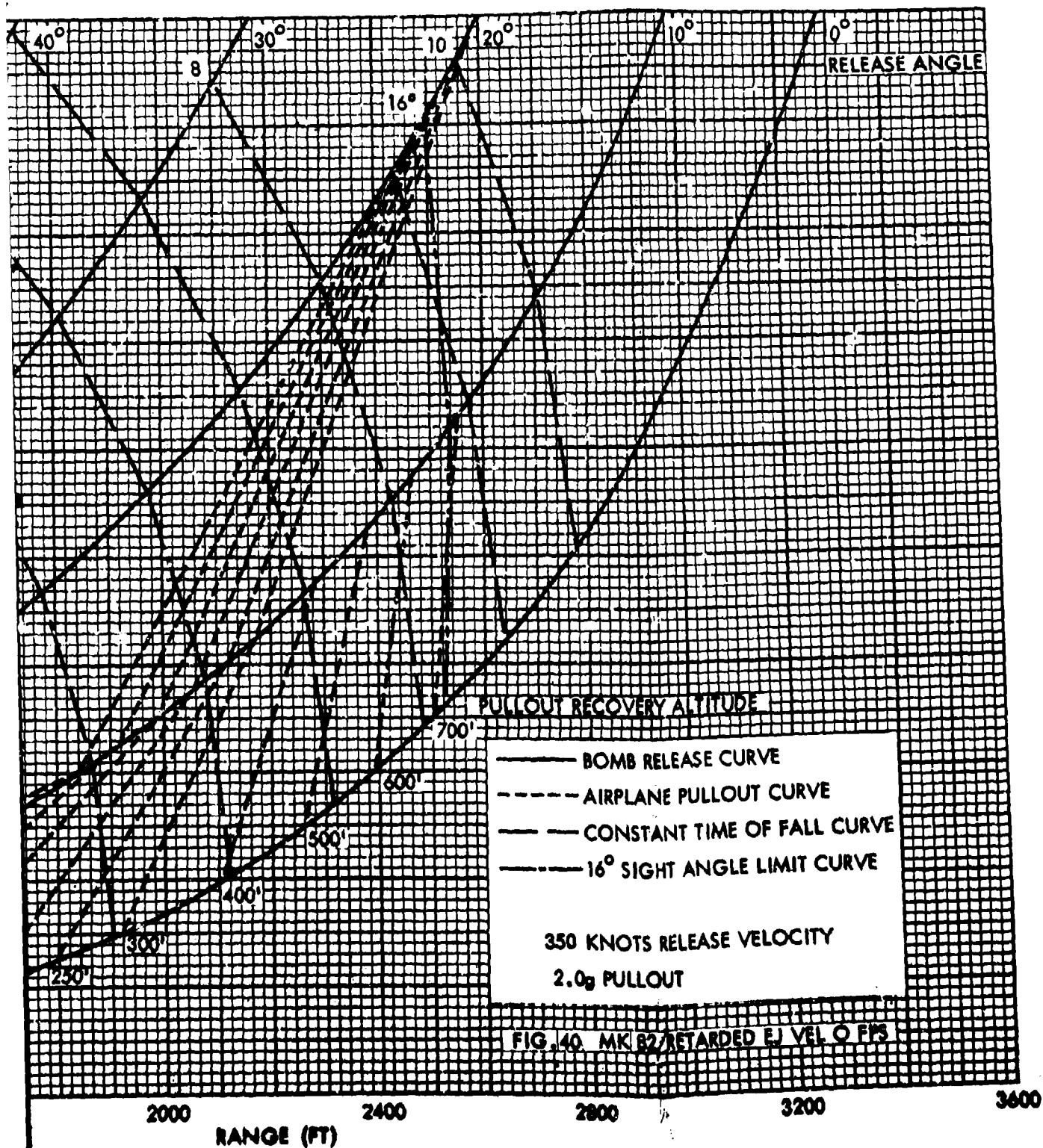


- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY
2.0g PULLOUT

FIG. 39 MK 82/RETARDED EJ VEL O FPS





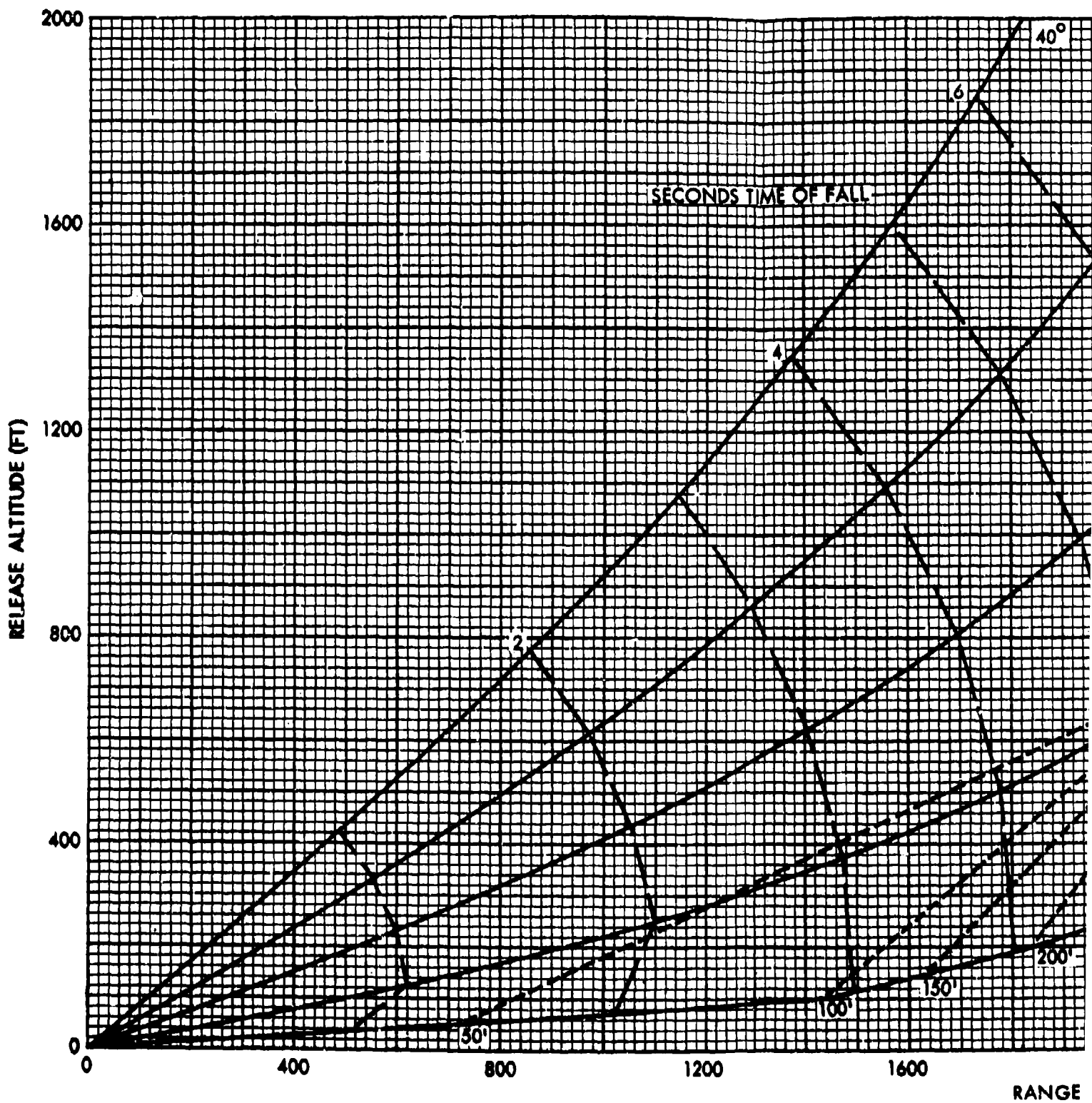
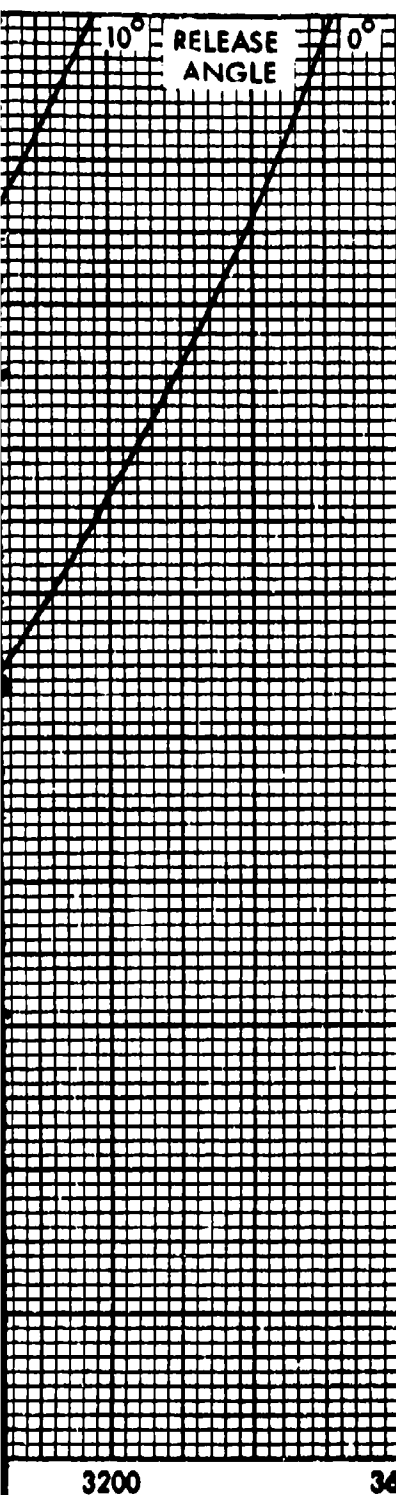




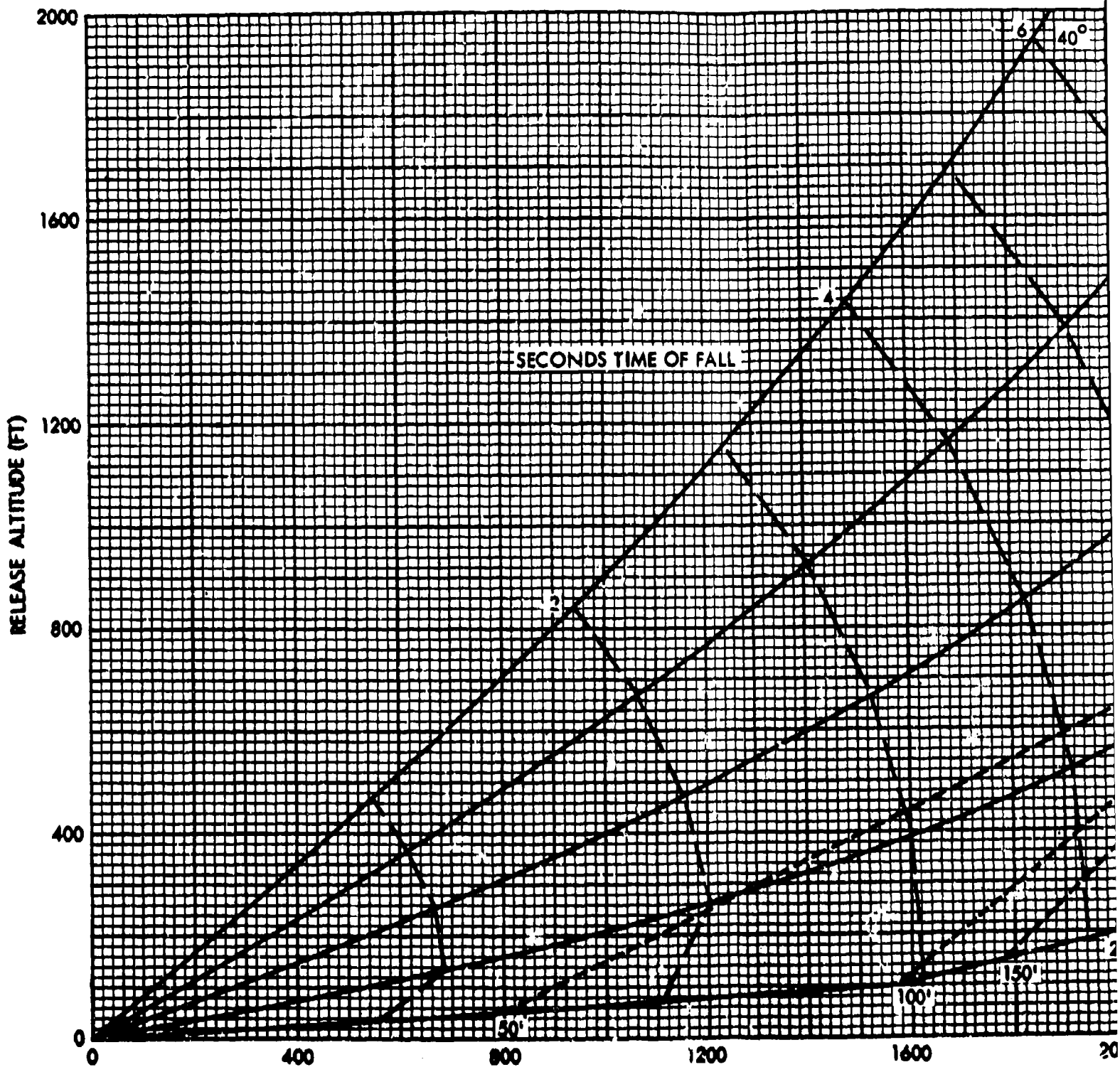
FIG. 41 MK



——— BOMB RELEASE CURVE
 - - - - AIRPLANE PULLOUT CURVE
 ——— CONSTANT TIME OF FALL CURVE
 - - - - 16° SIGHT ANGLE LIMIT CURVE

400 KNOTS RELEASE VELOCITY
 2.0g PULLOUT

FIG. 41 MK 82/RETARDED EJ VEL O FPS



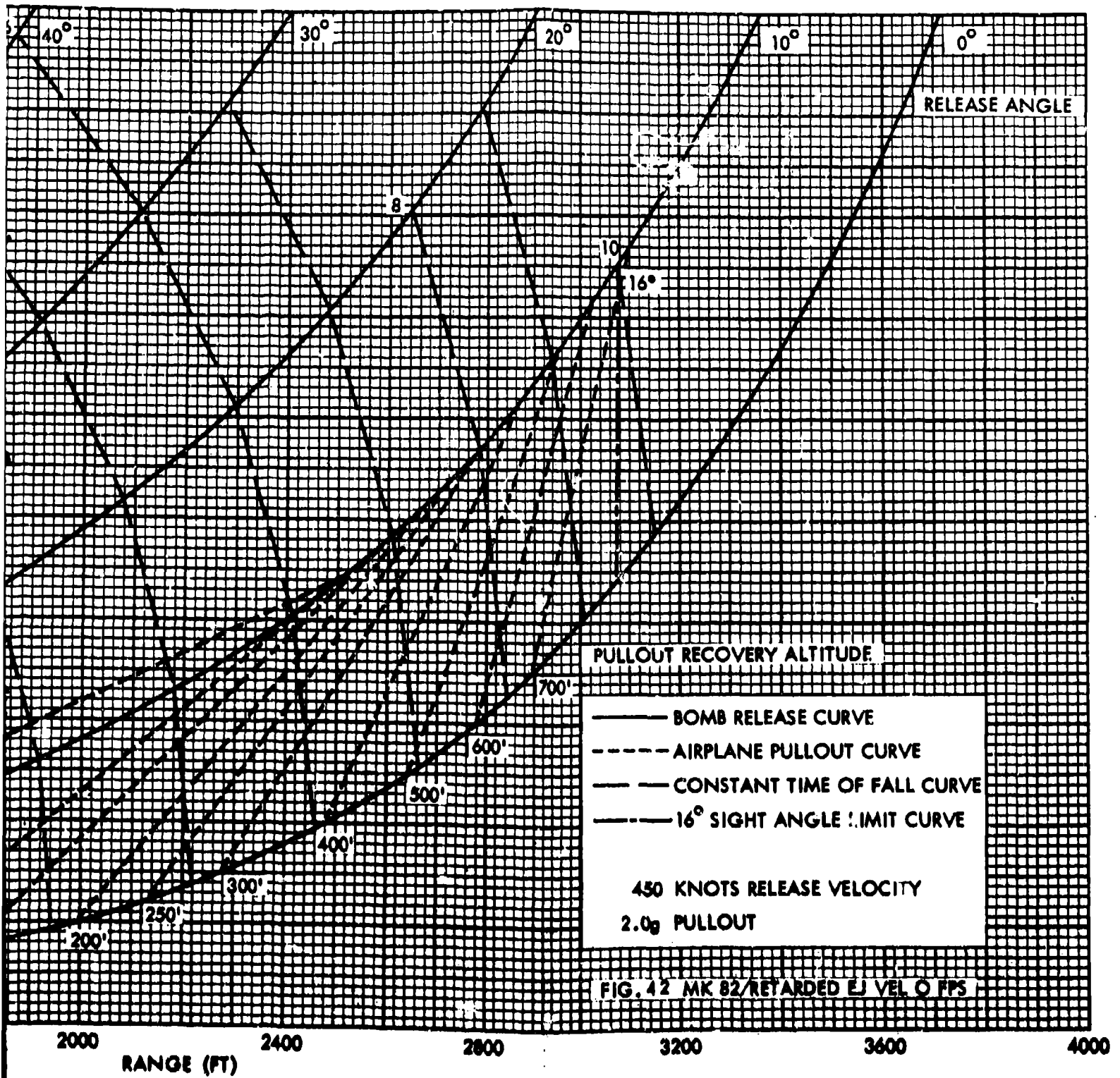
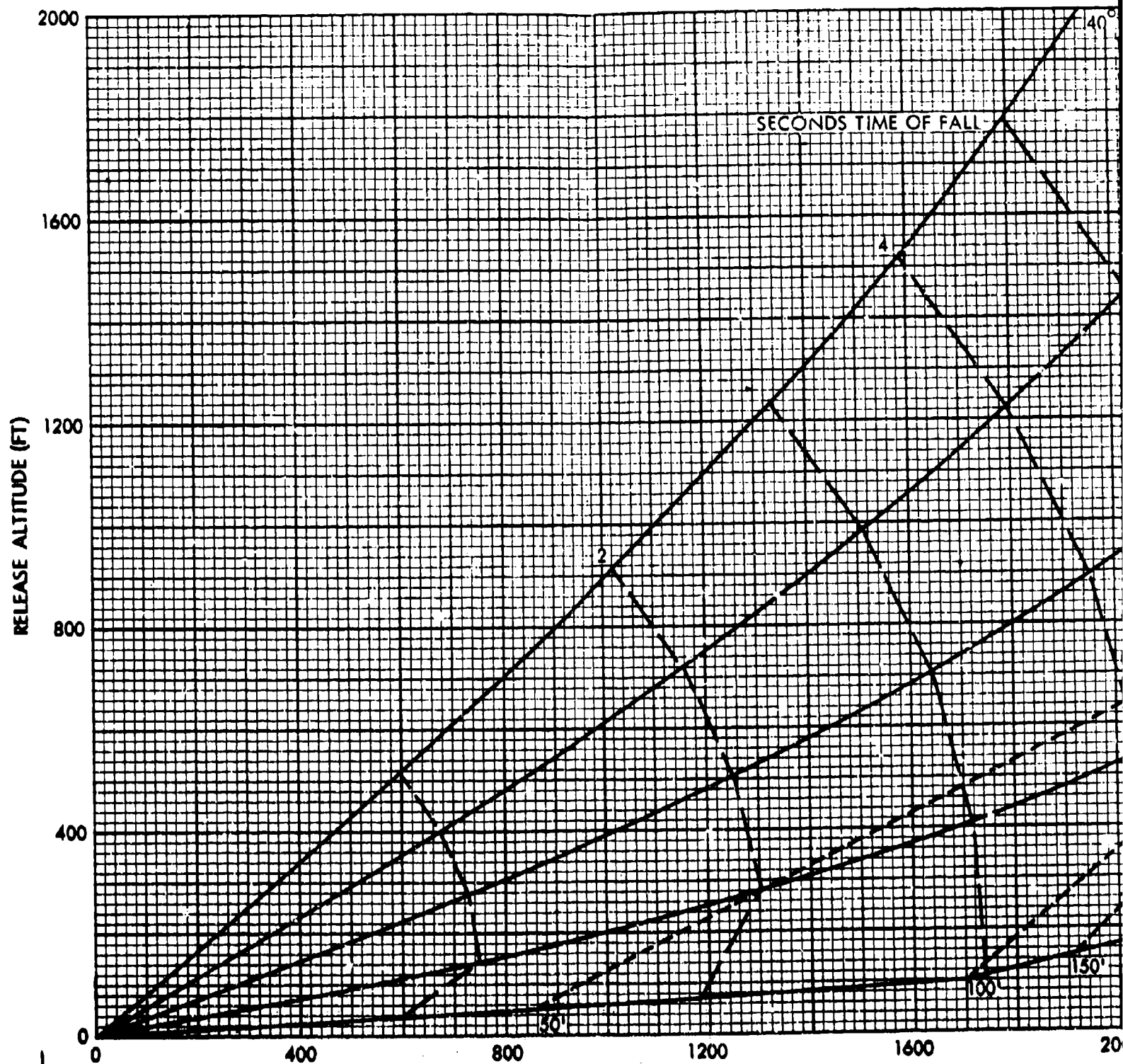
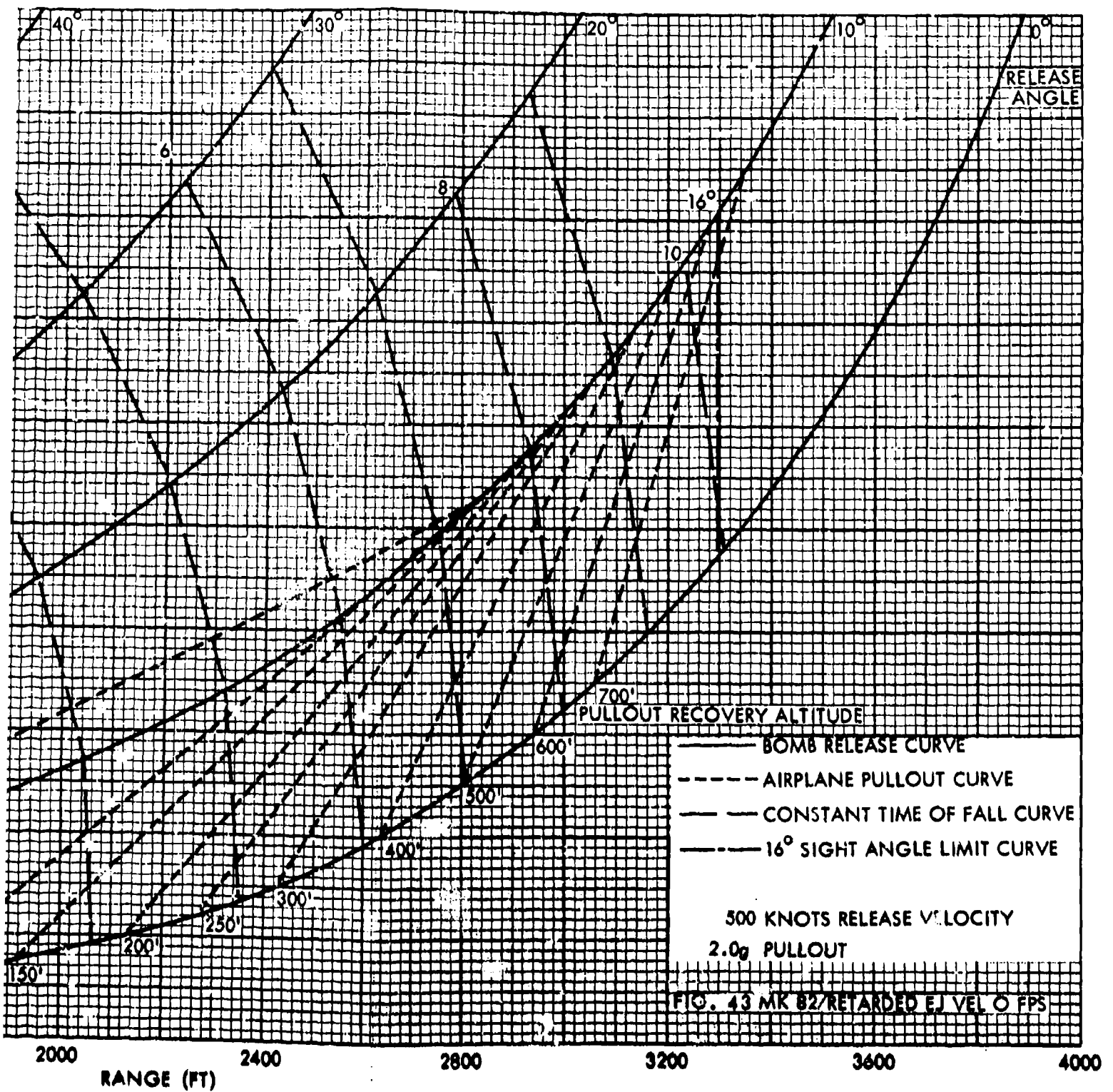
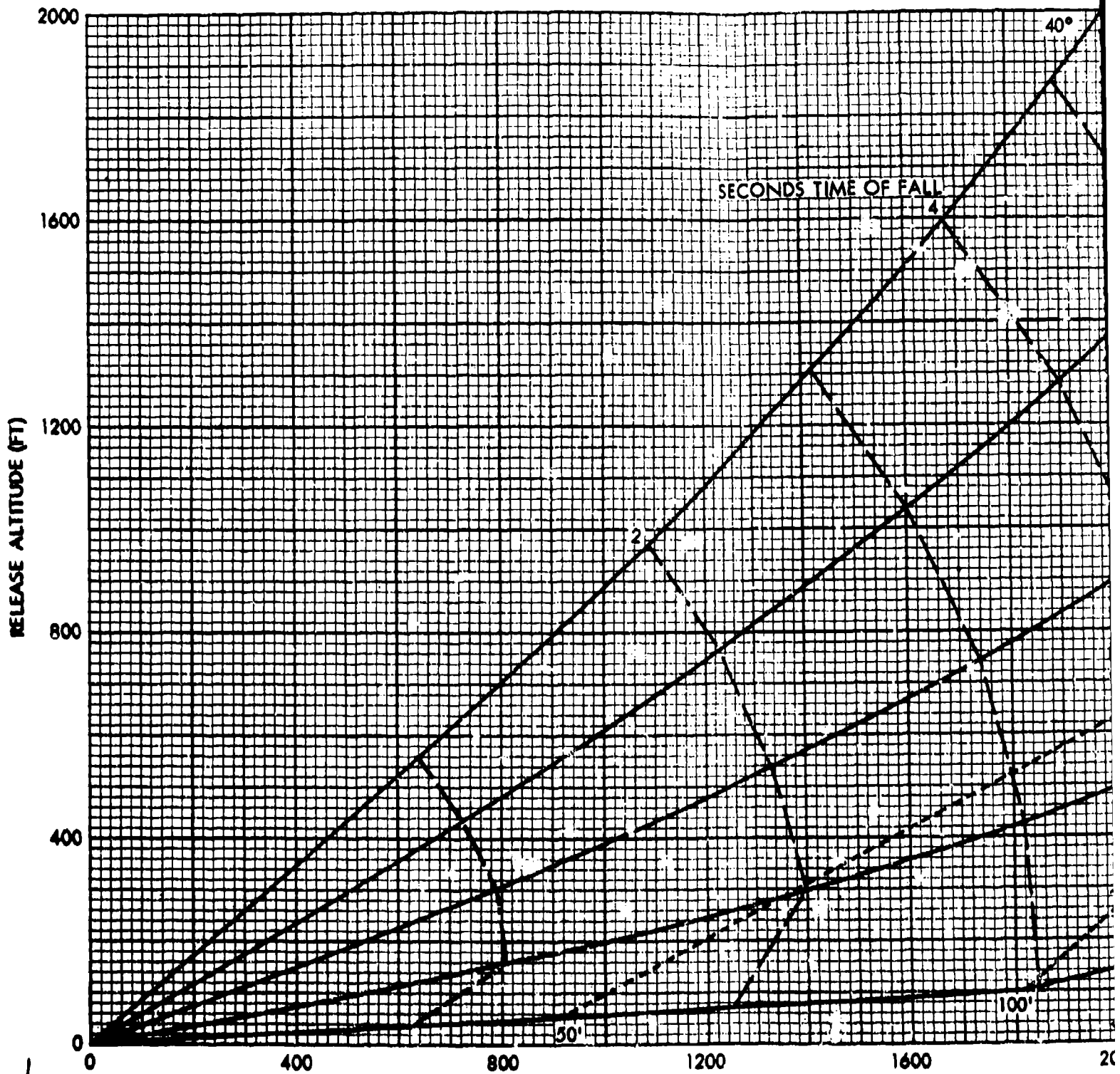
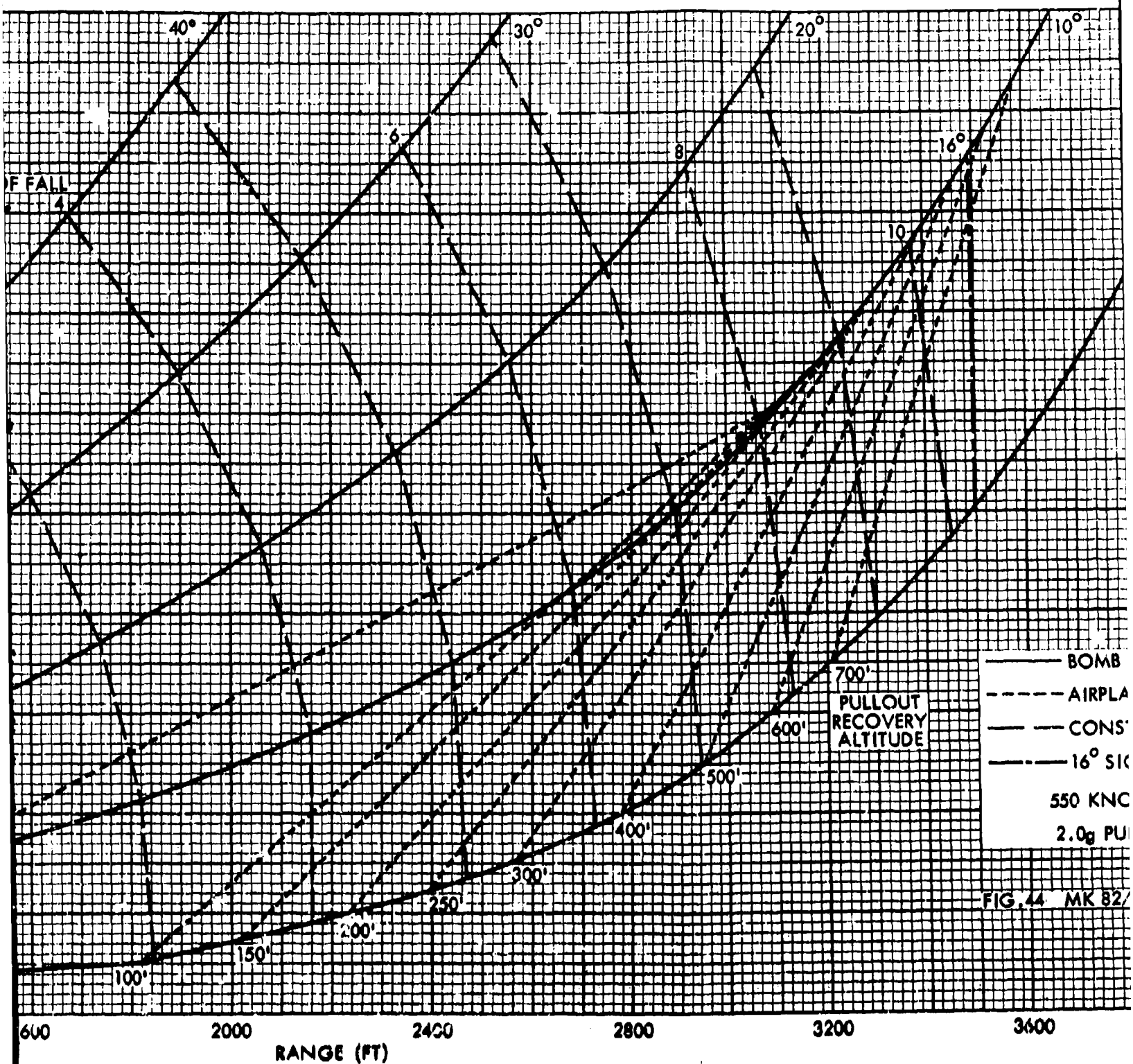


FIG. 42 MK 82/RETARDED EJ VEL 0 FPS

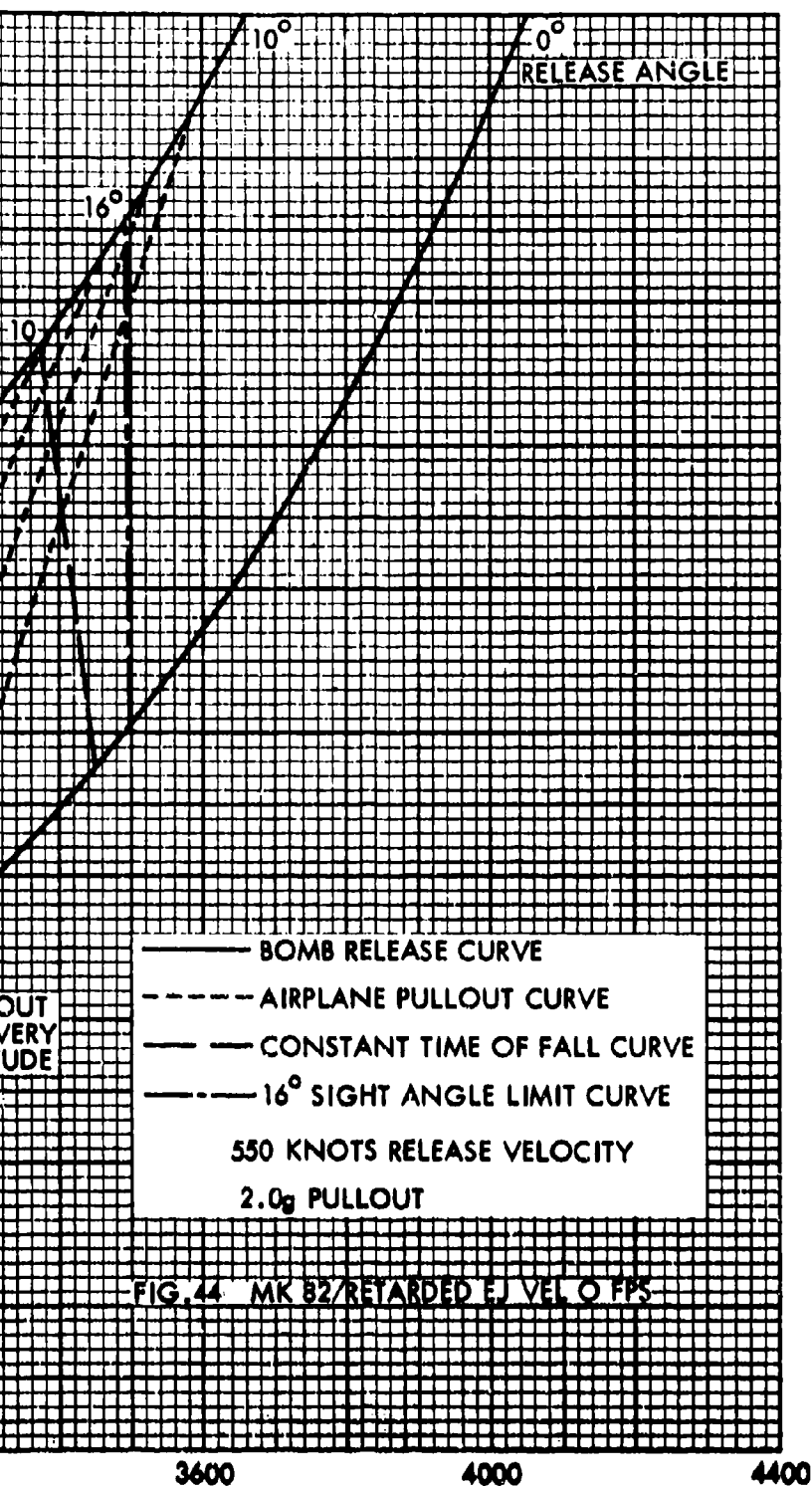


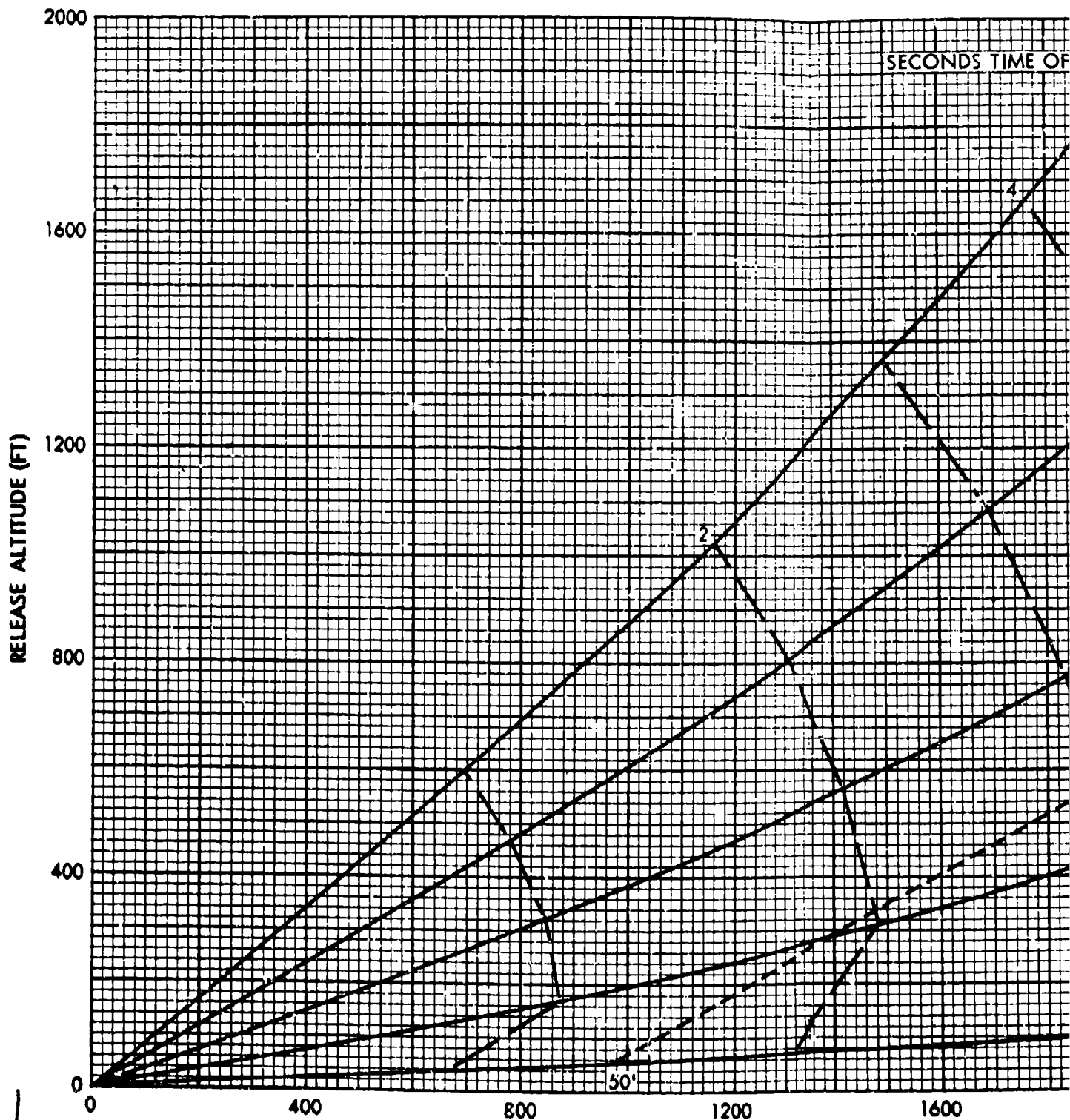


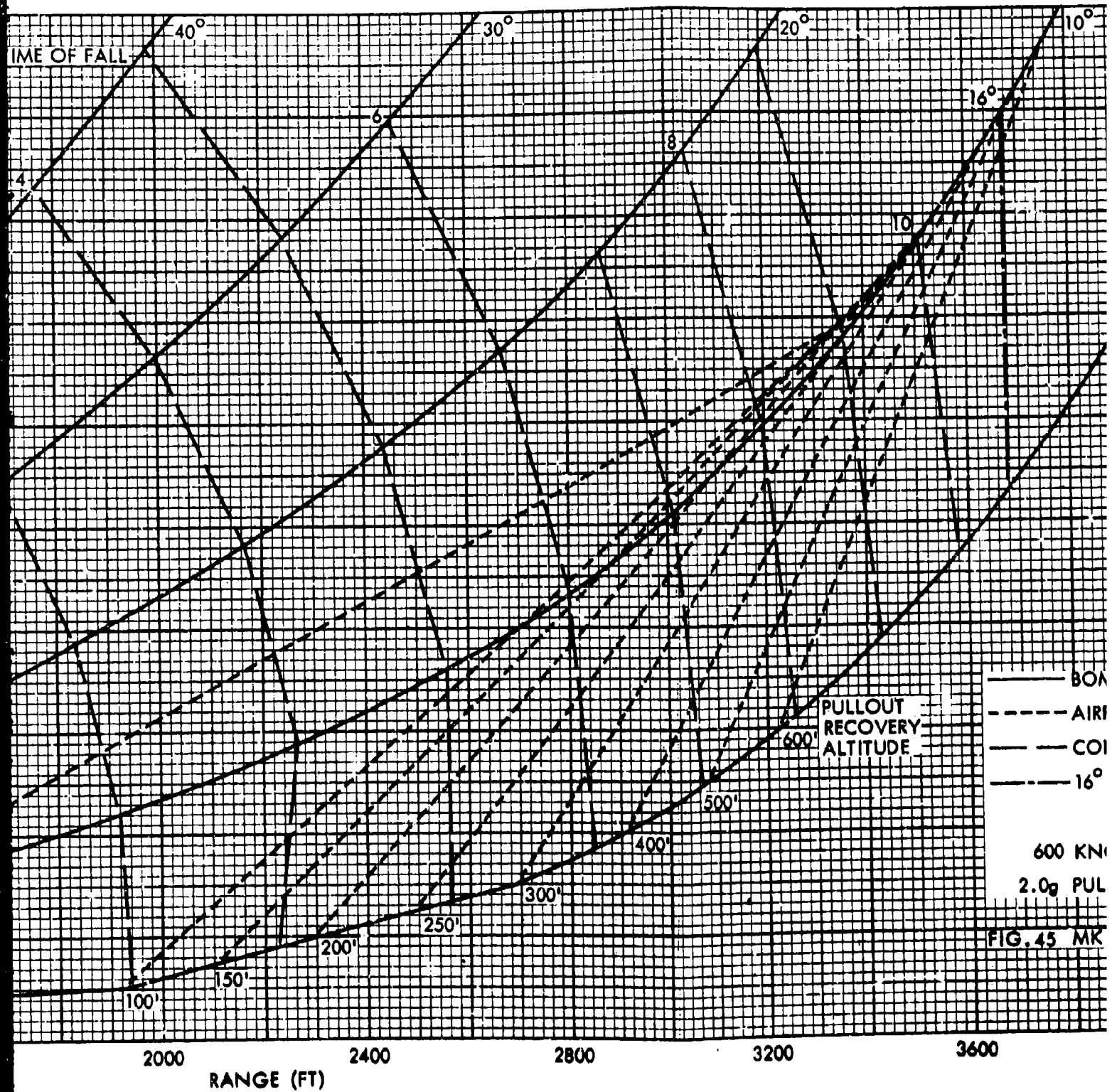




2







2

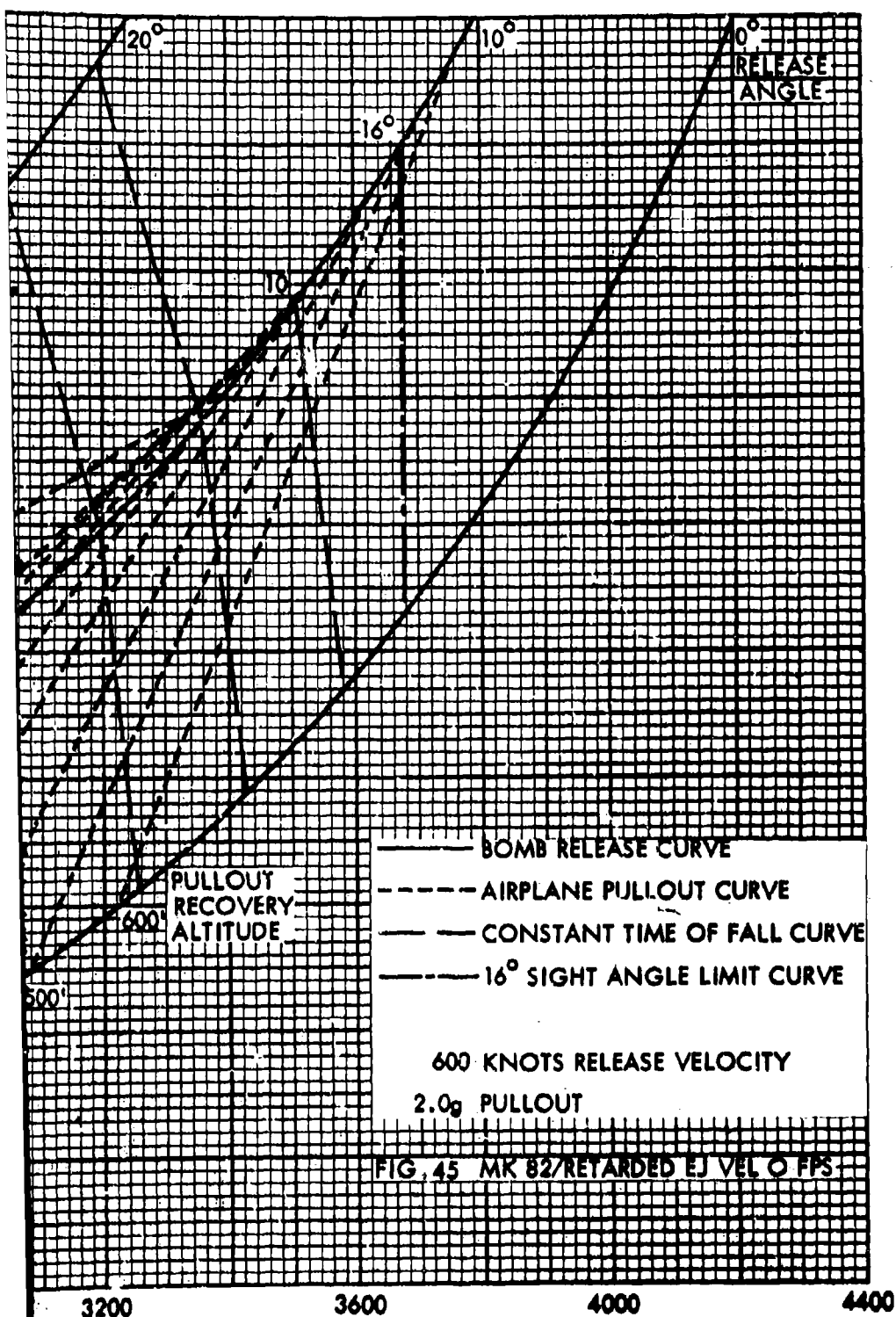
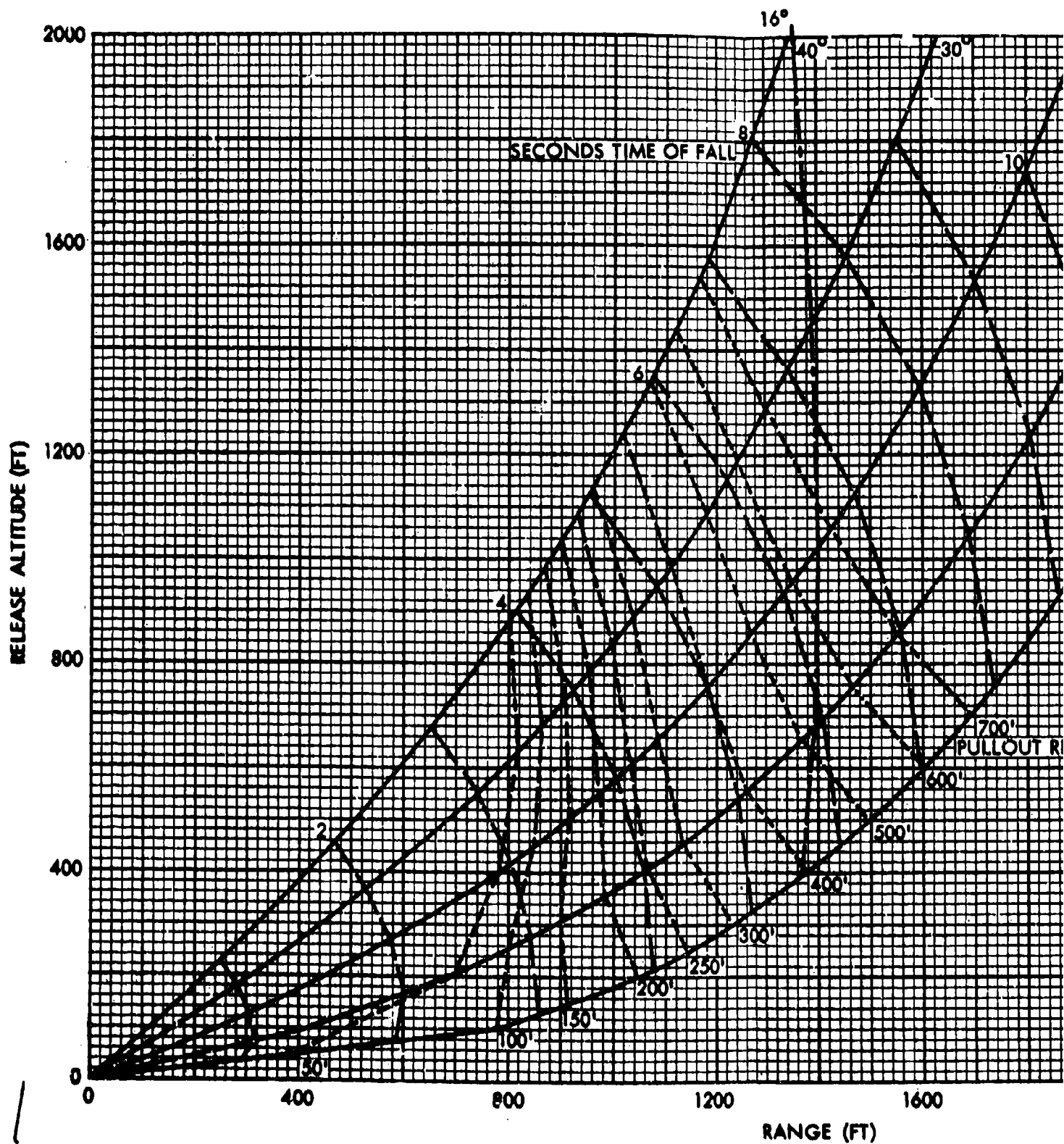
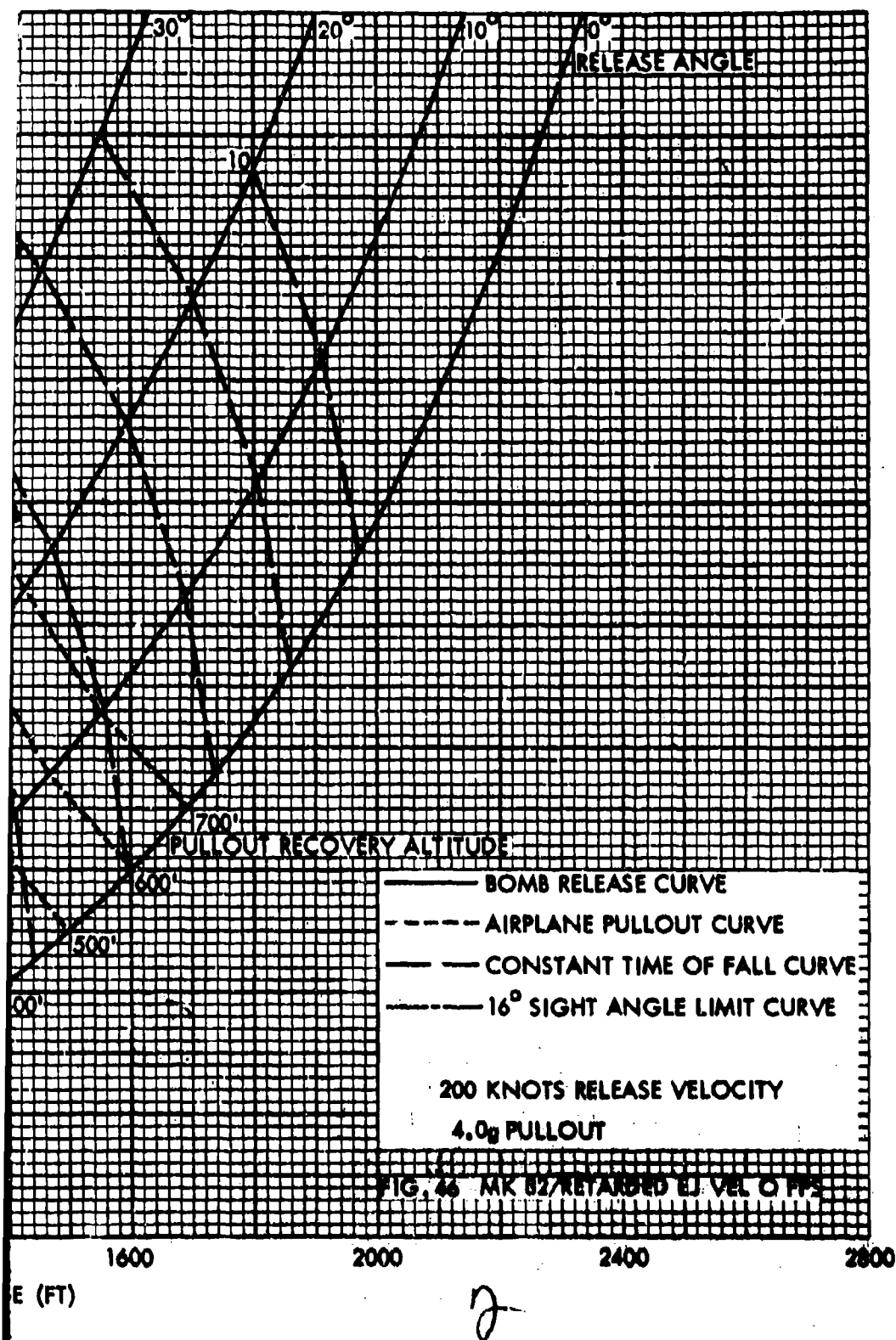
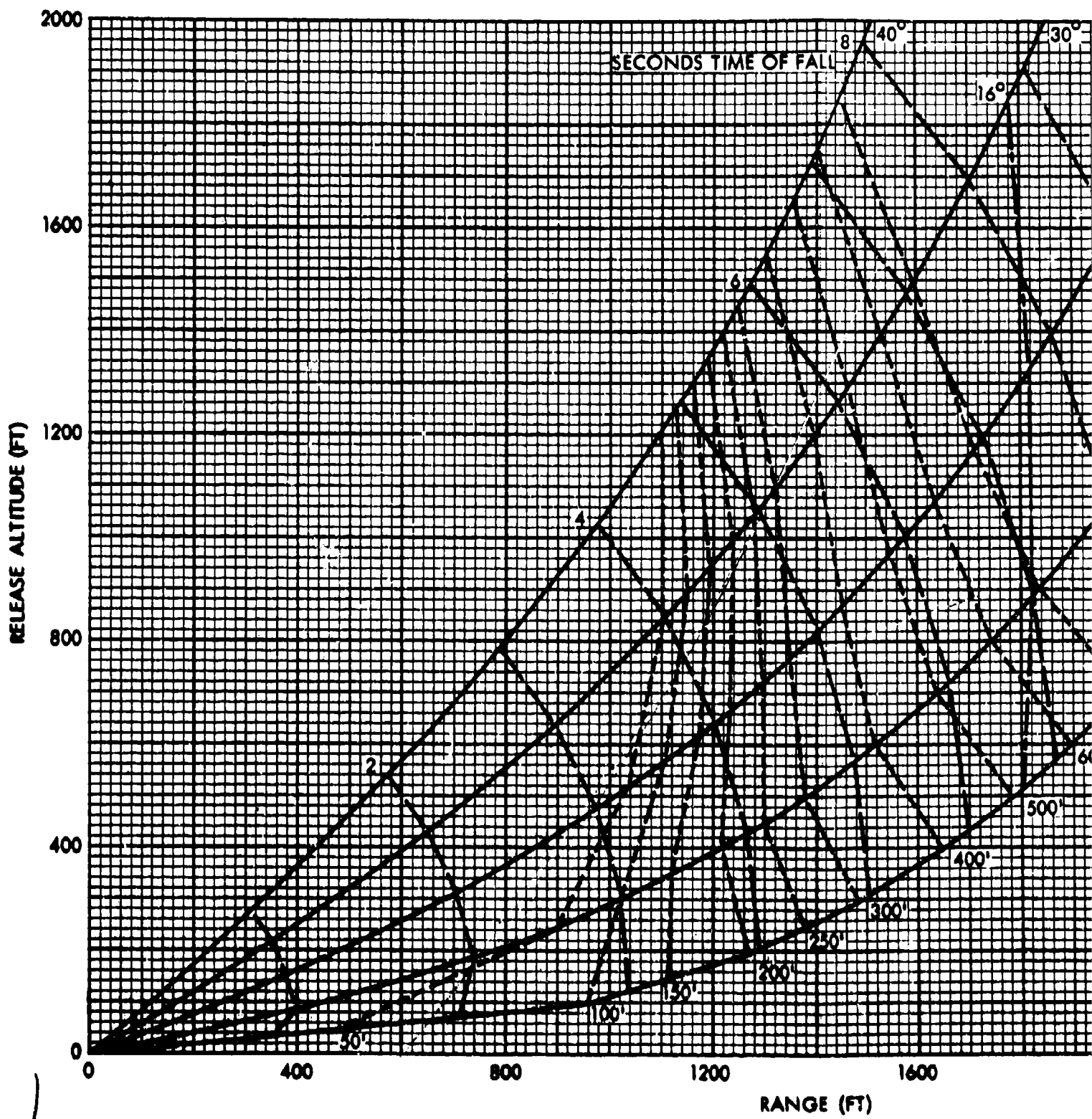


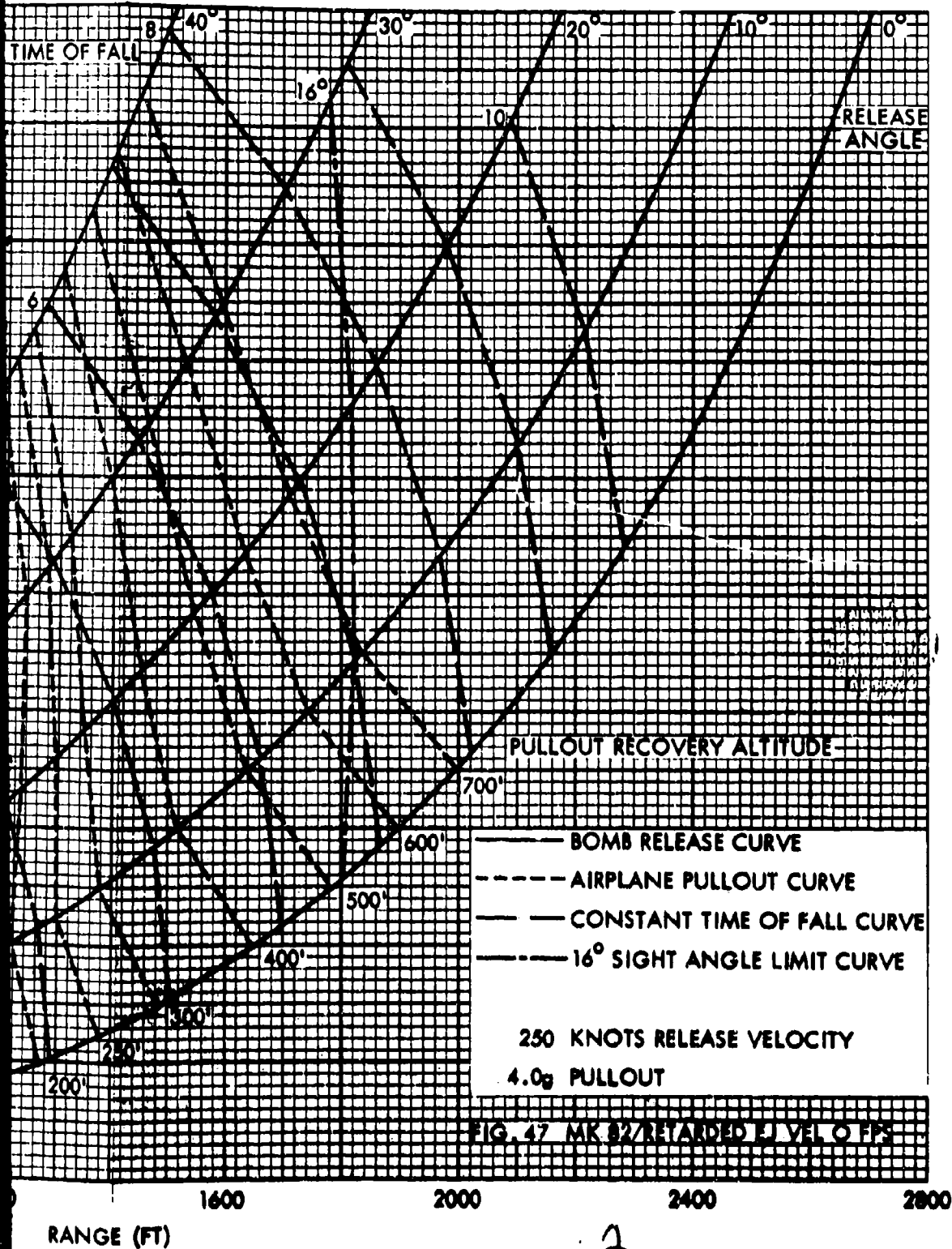
FIG. 45 MK 82/RETARDED EJ VEL O FPS

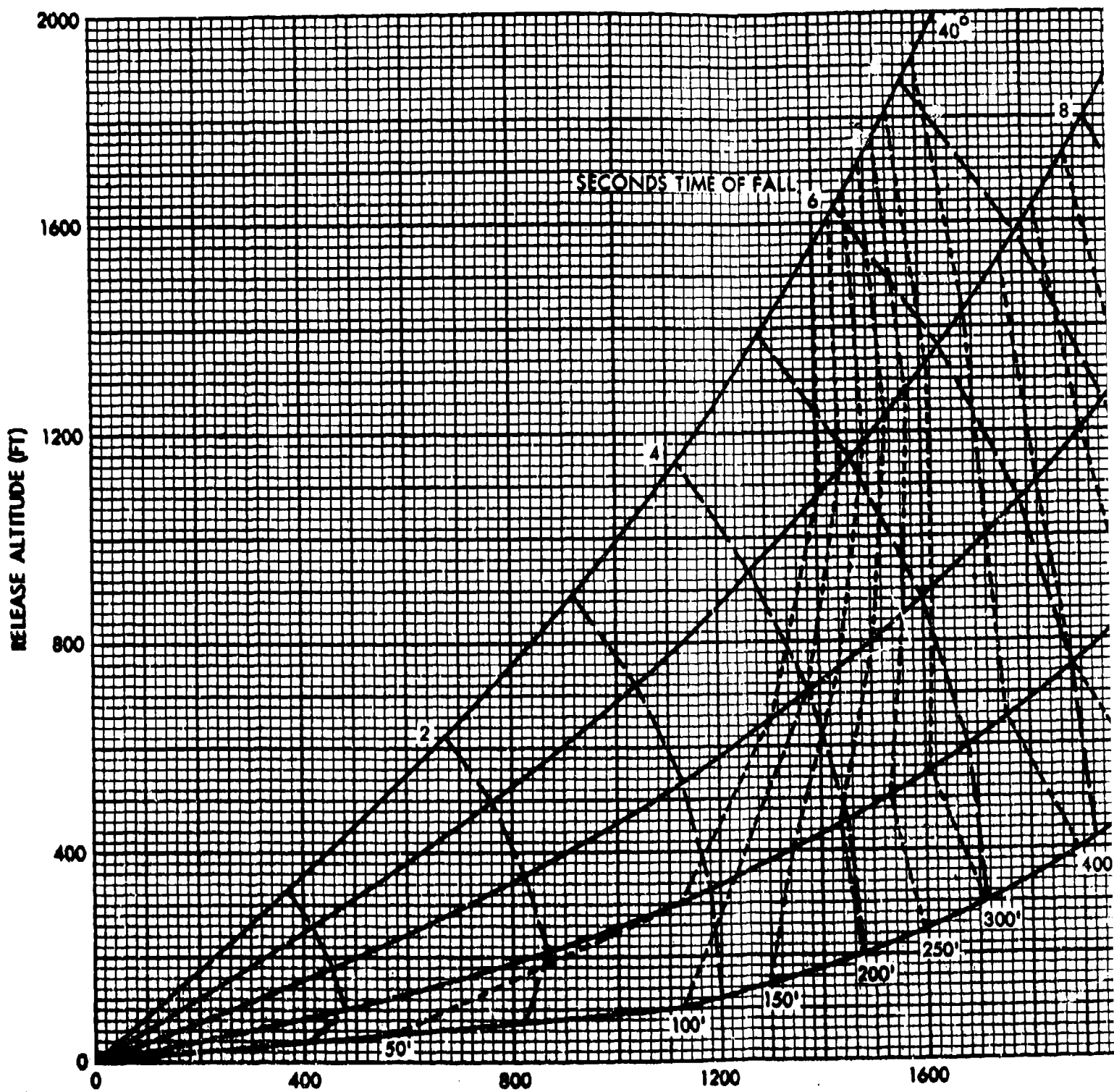


NOLTR 65-230









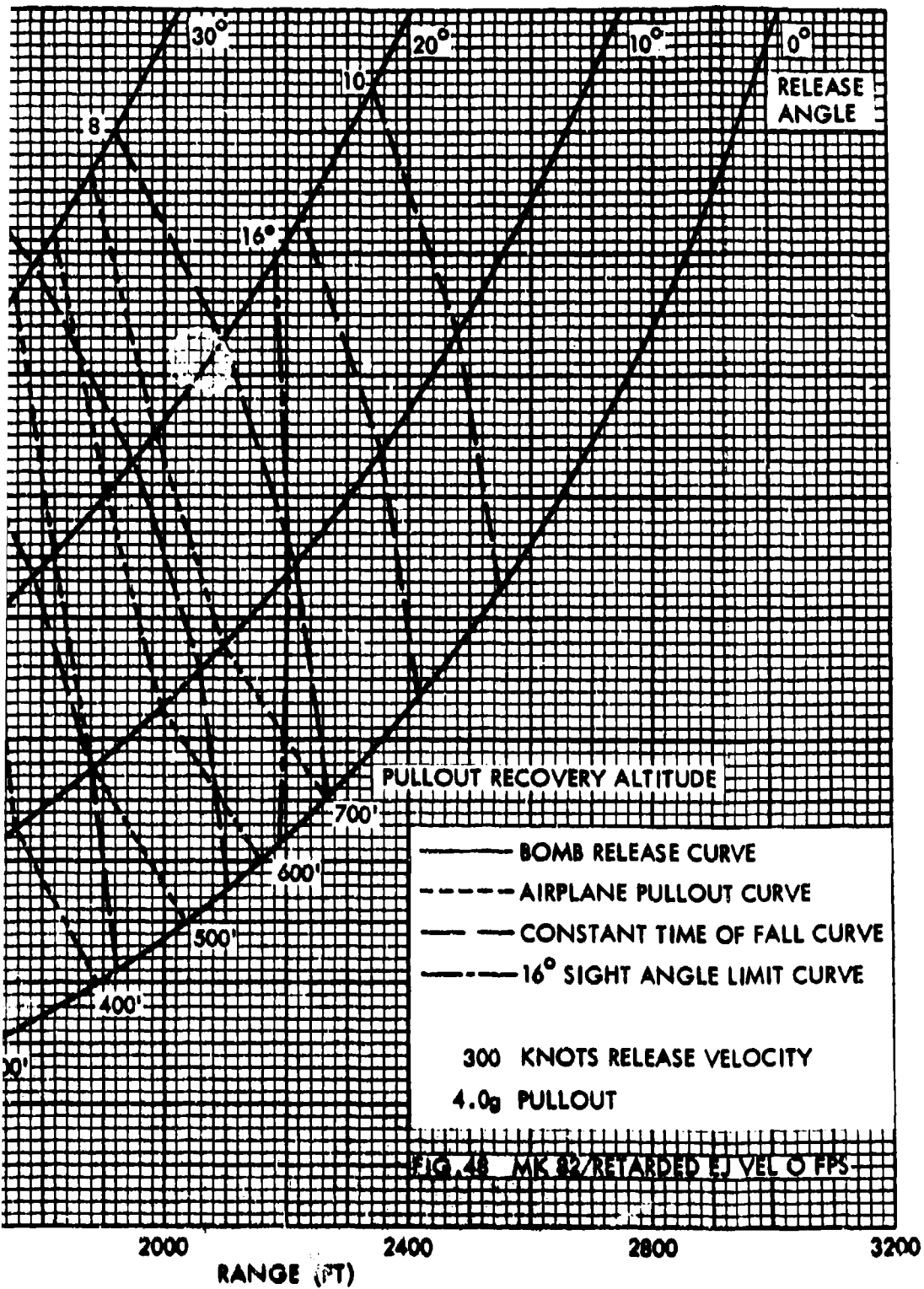
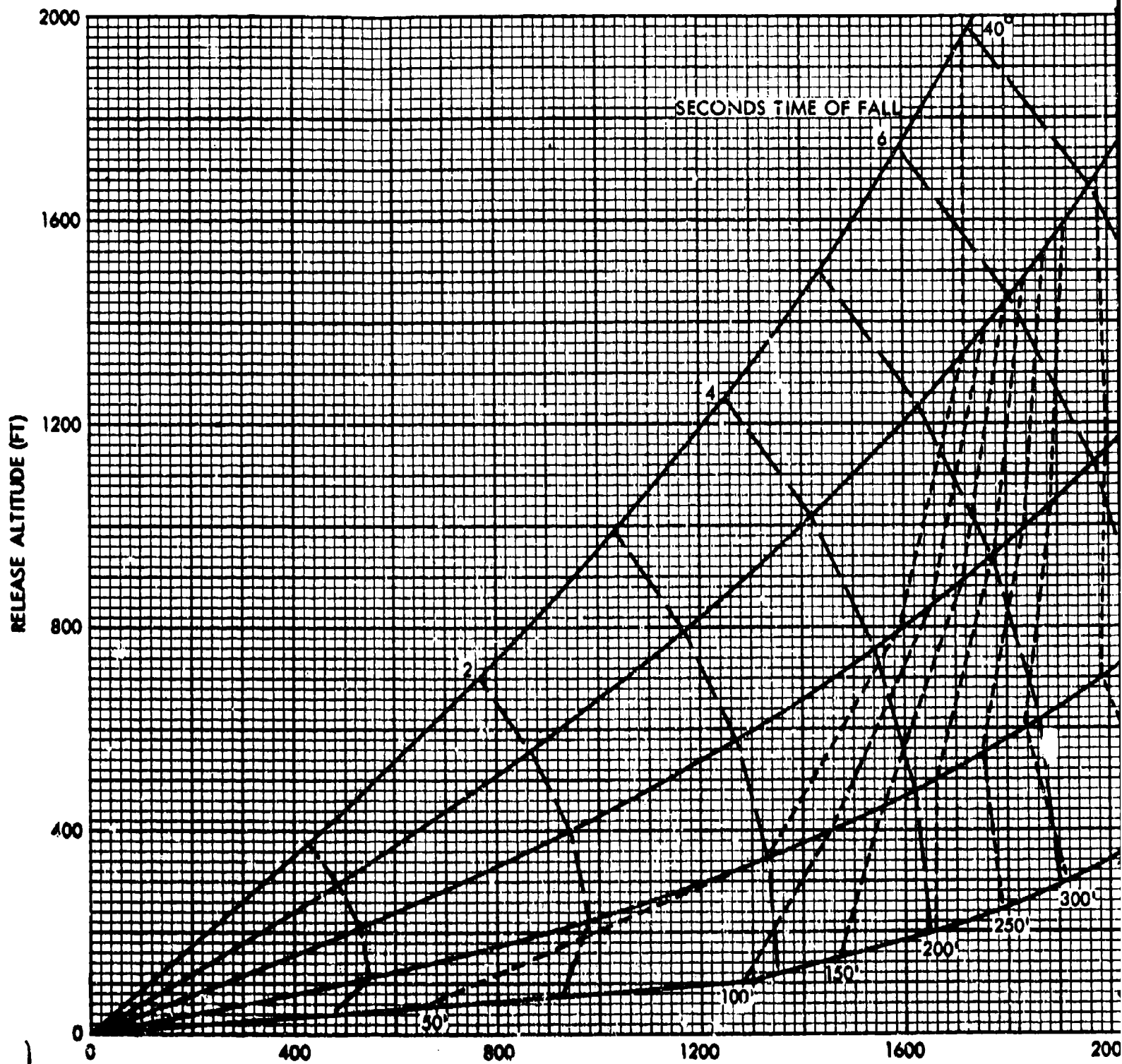
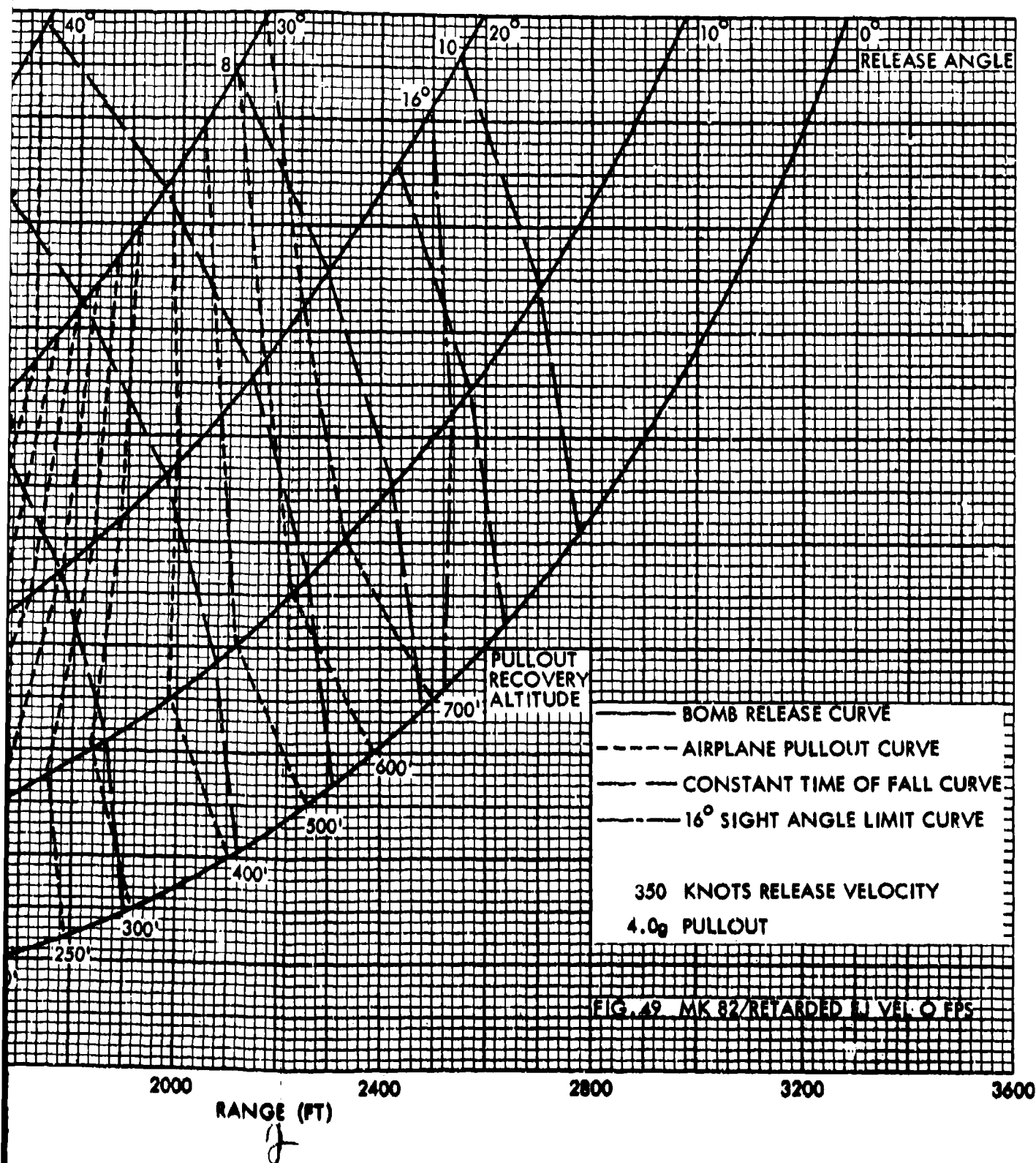
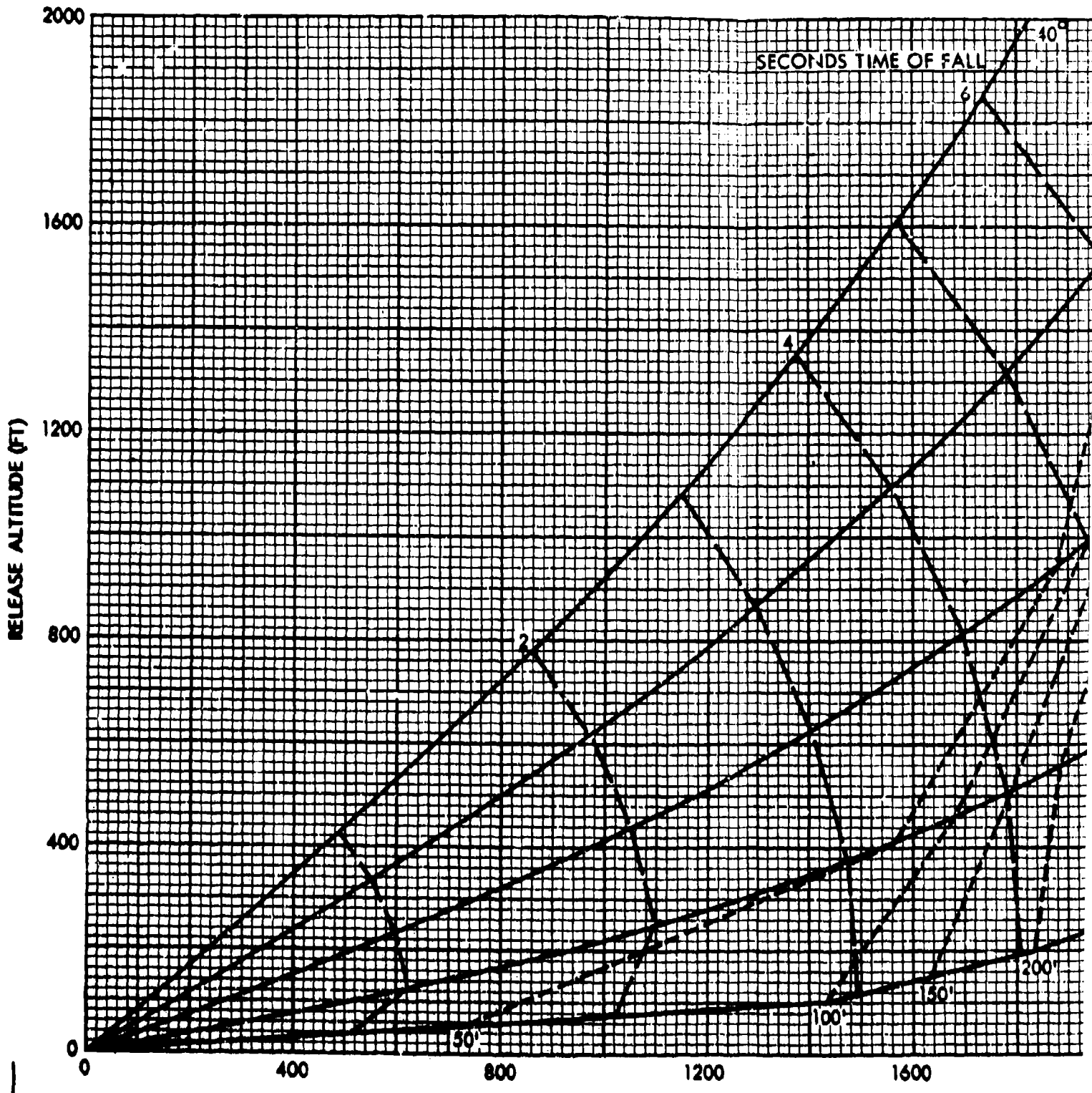


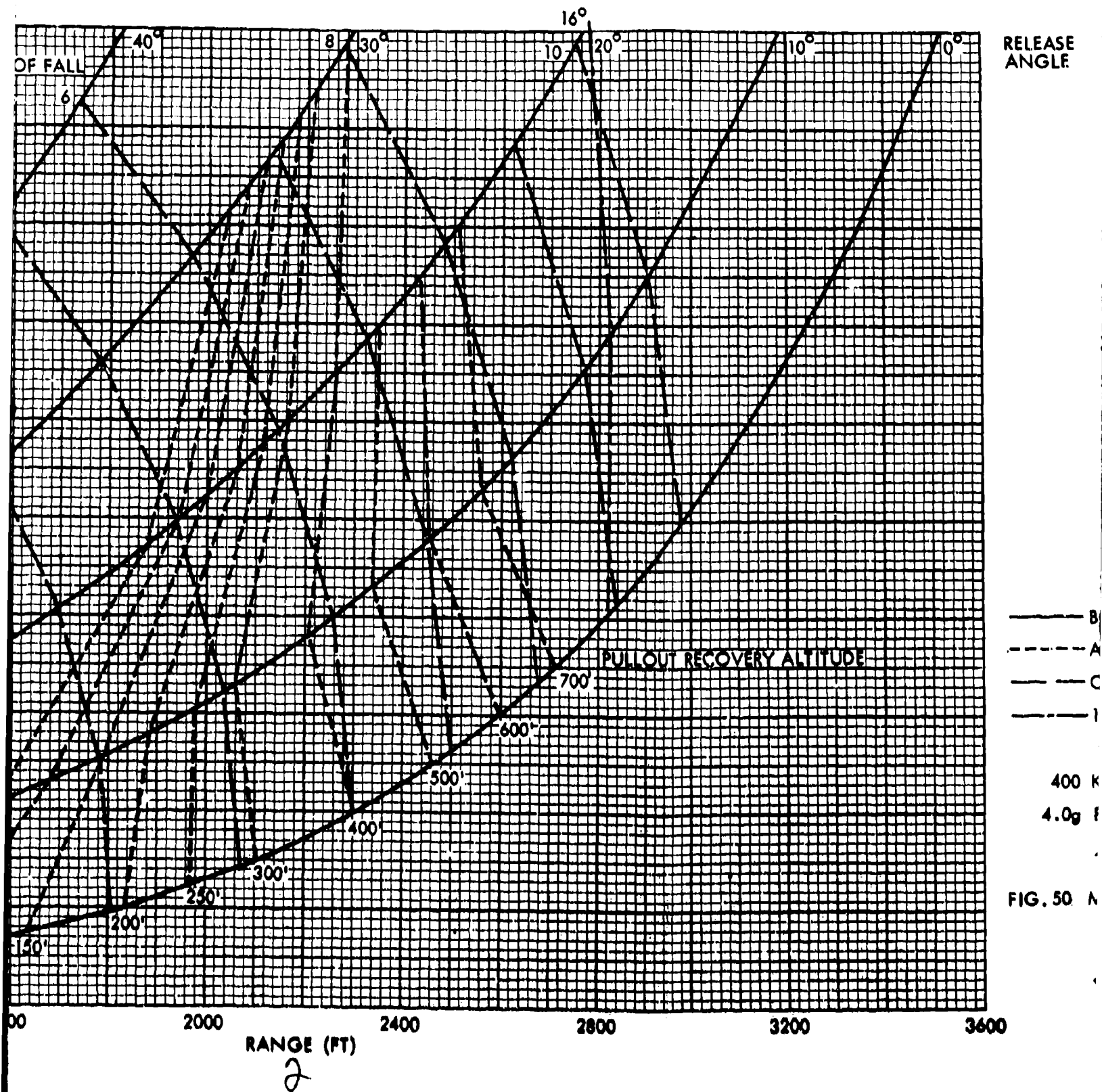
FIG. 48 MK 82/RETARDED EJ VEL 0 FPS







NOLTR 65-230



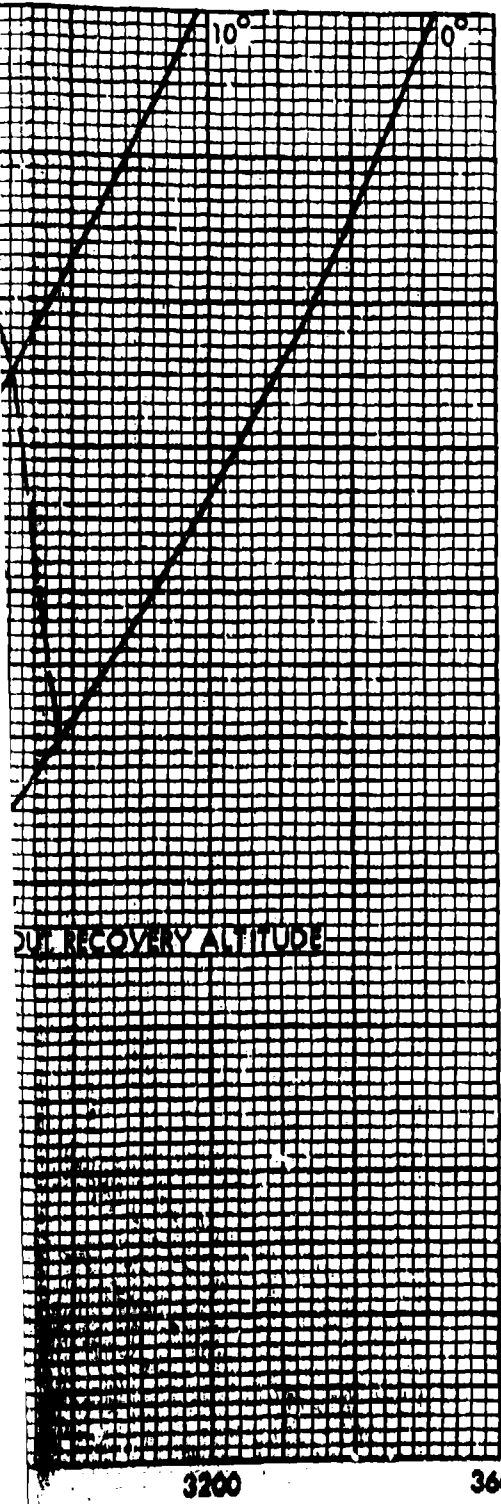
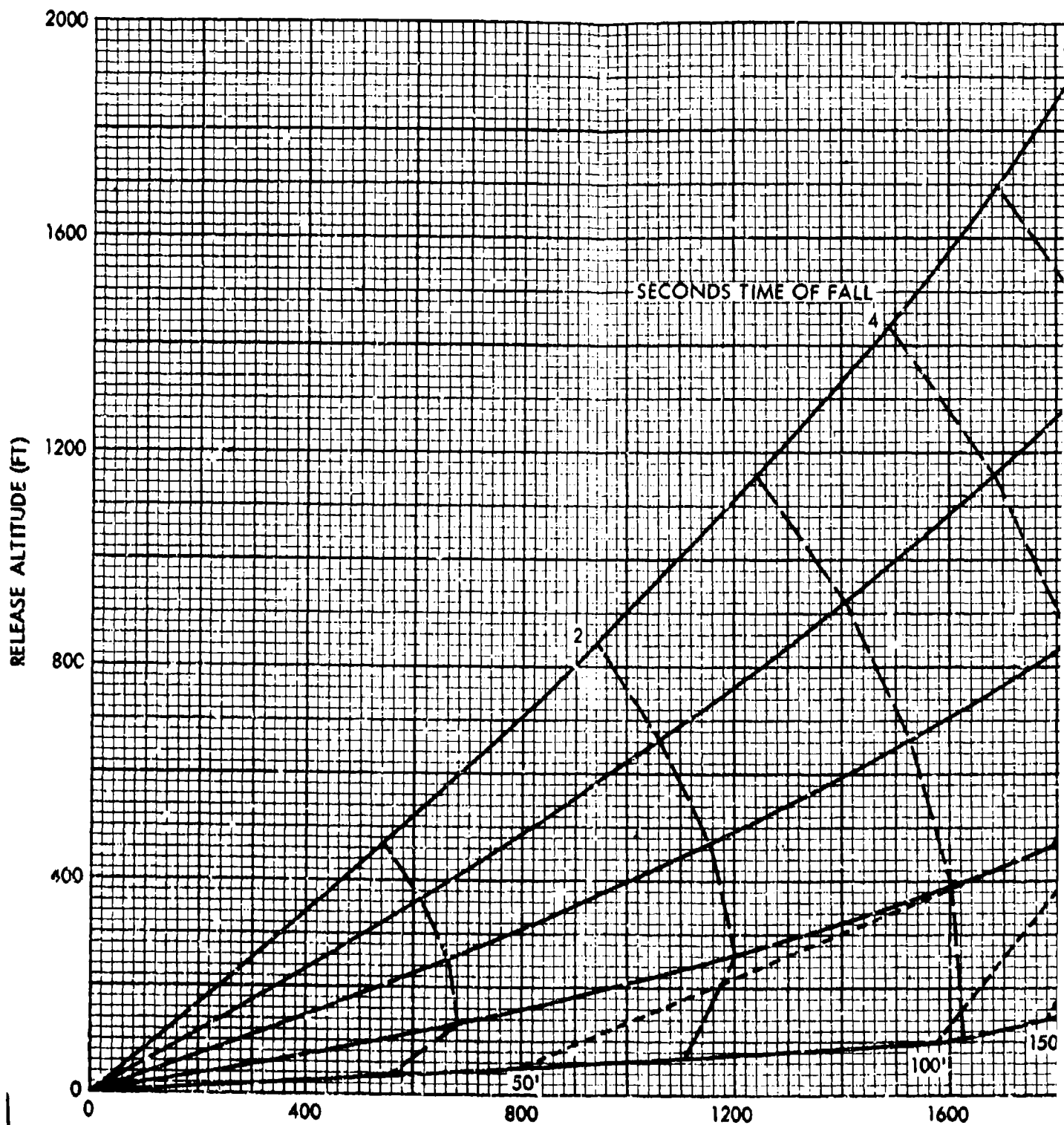
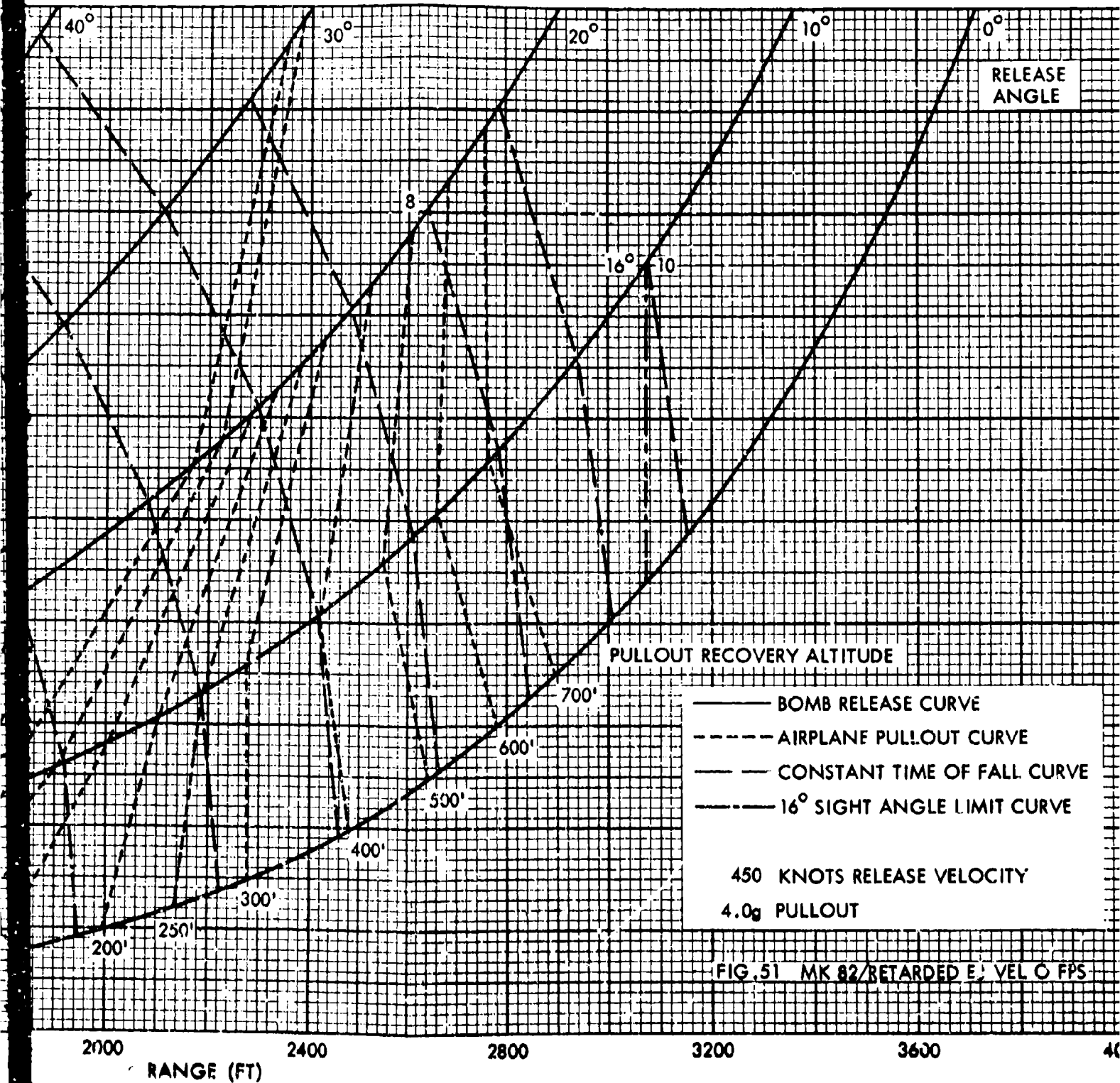
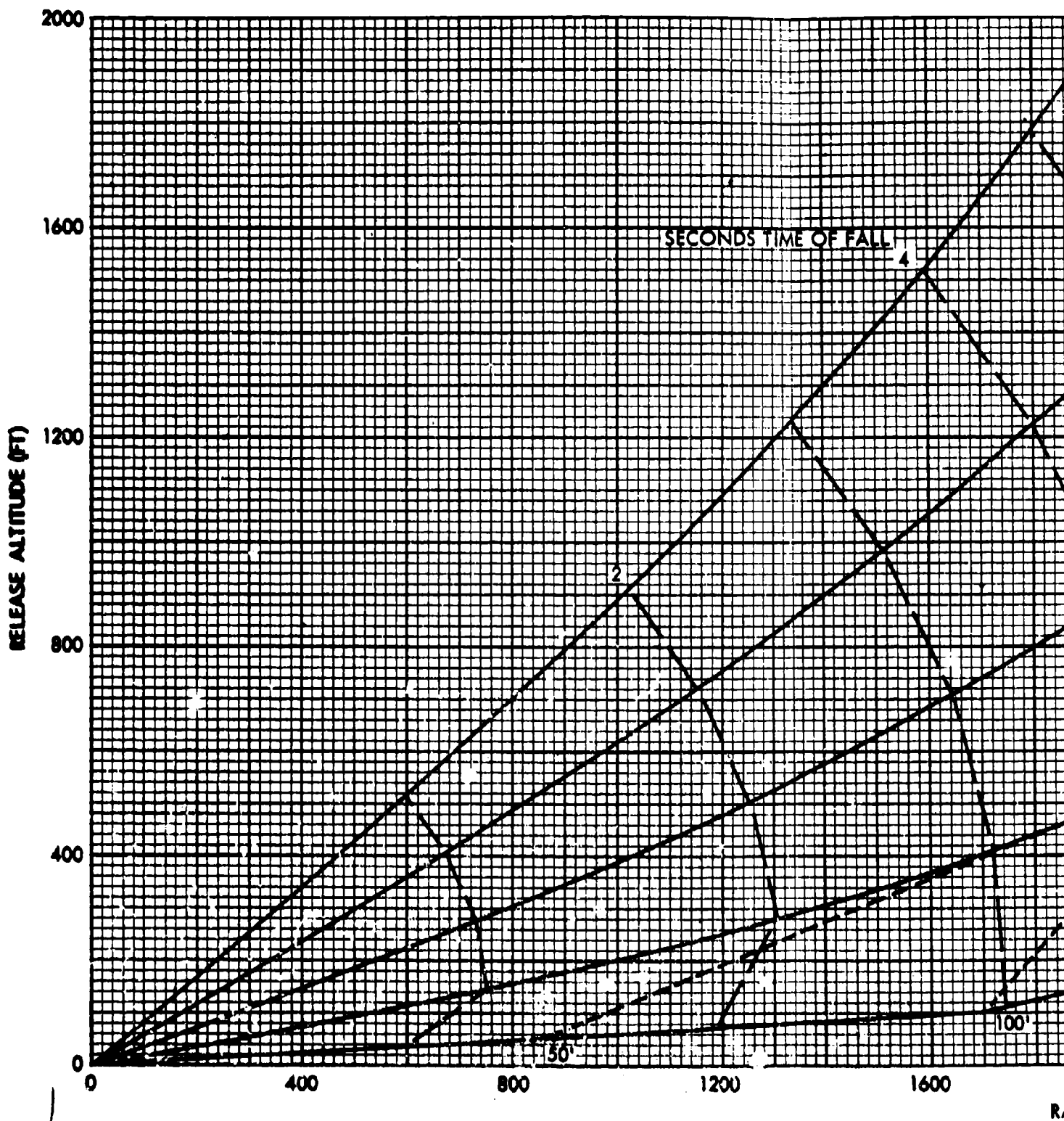
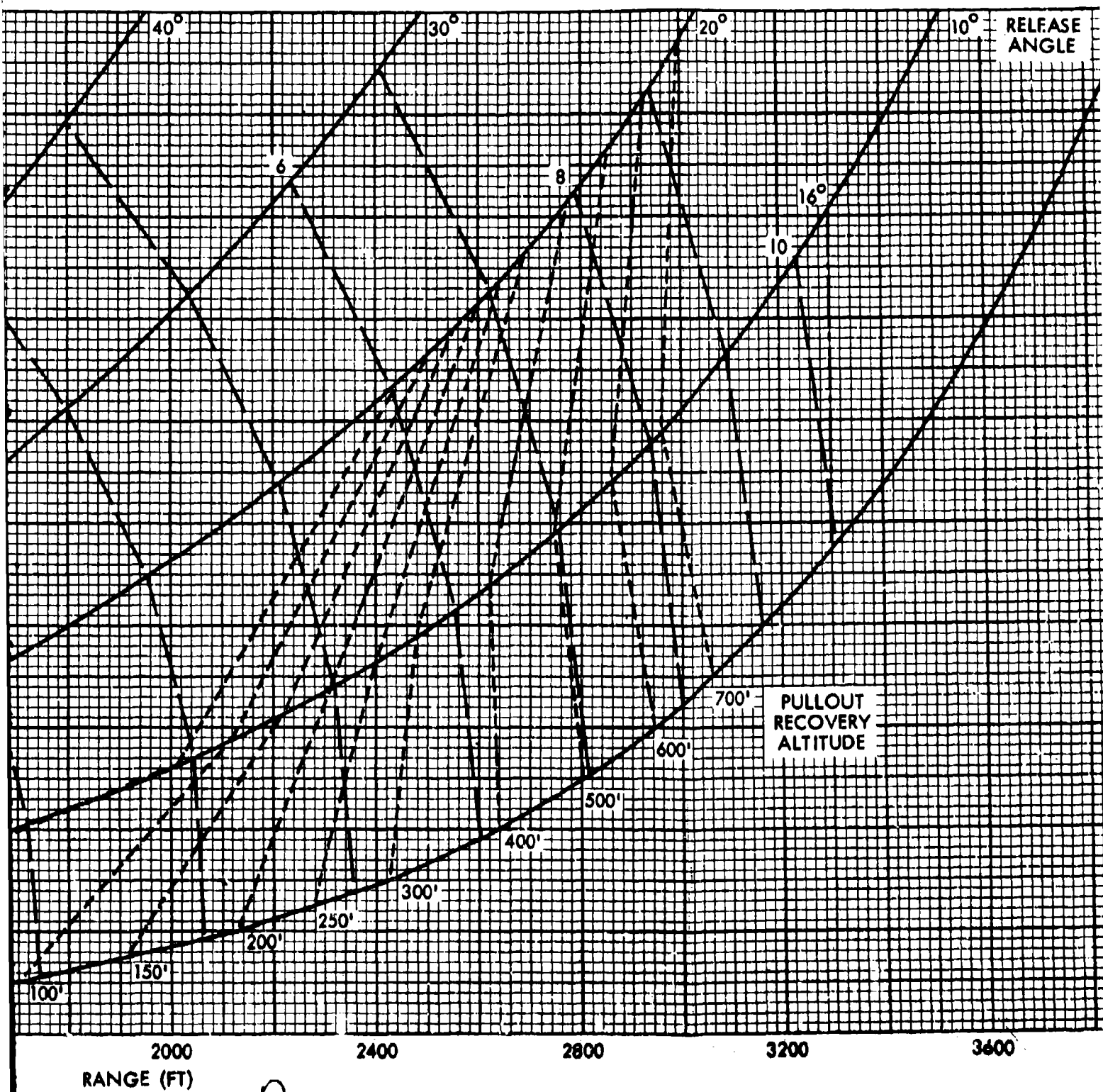


FIG. 50. MK 82/RETARDED EJ VEL O FPS



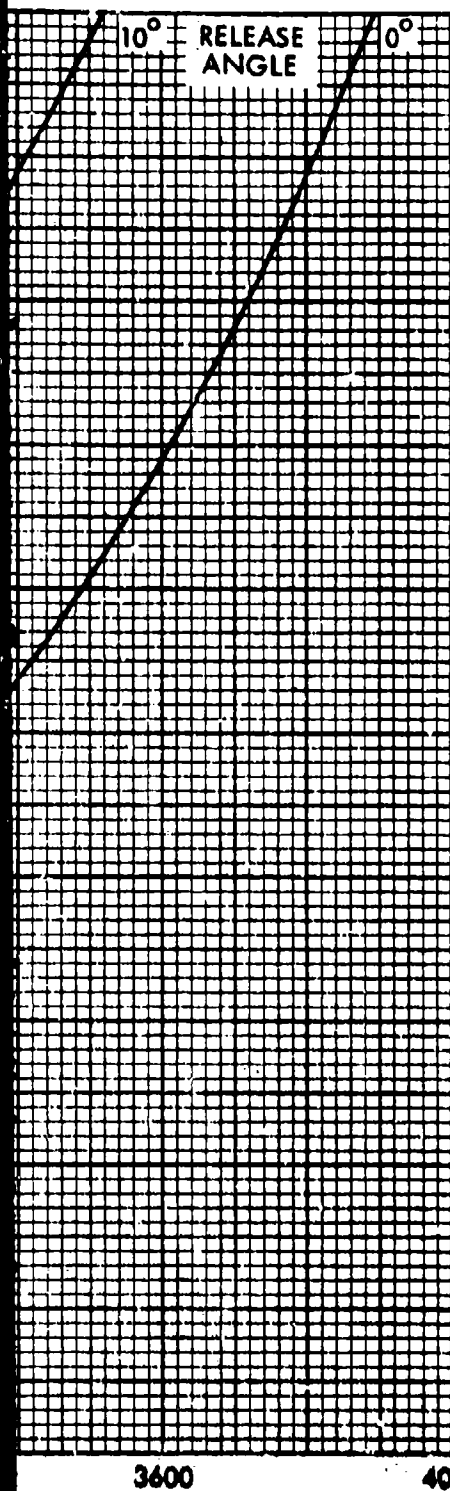






2

NOLTR 65-230

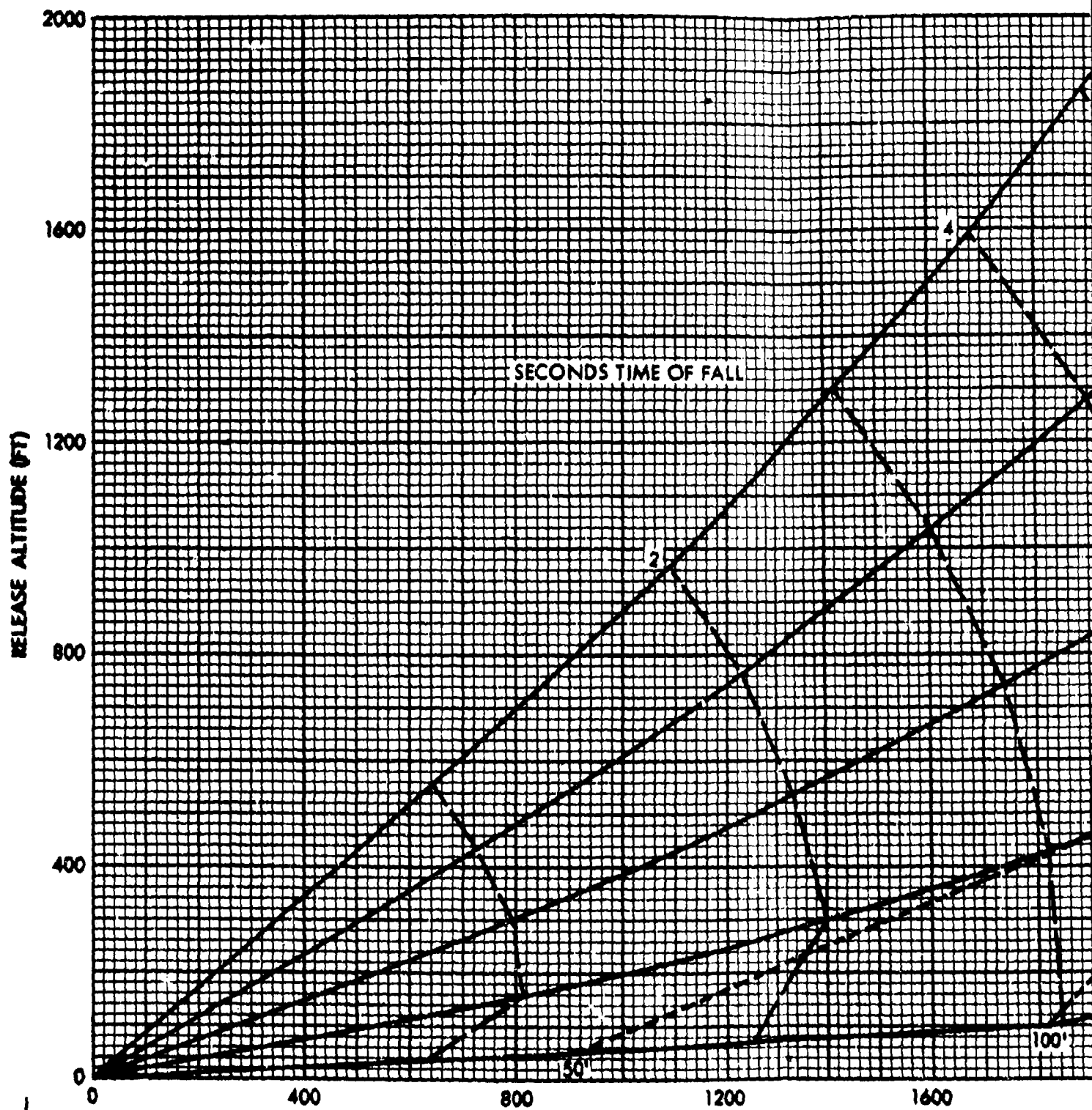


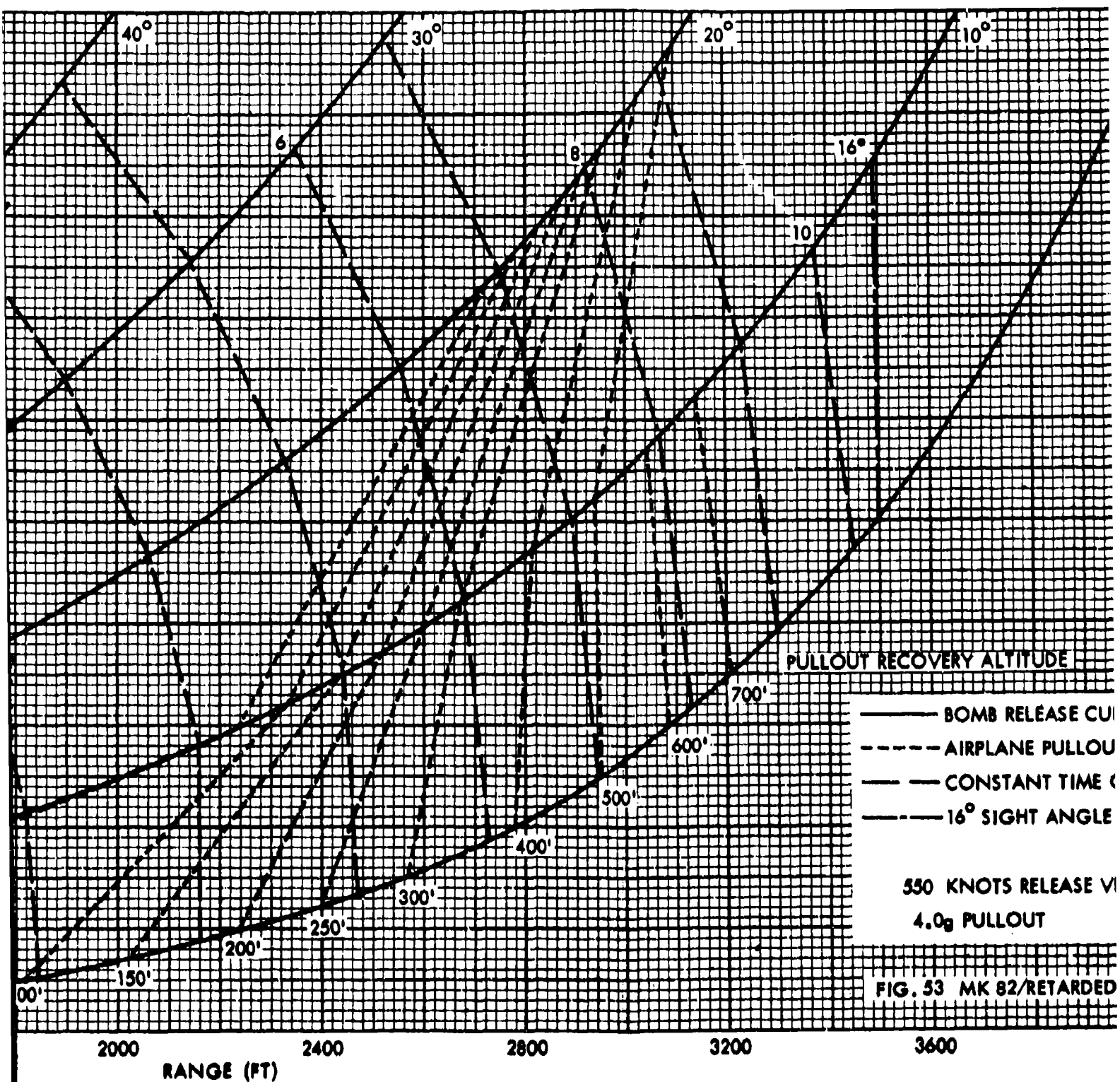
—— BOMB RELEASE CURVE
----- AIRPLANE PULLOUT CURVE
—— CONSTANT TIME OF FALL CURVE
----- 16° SIGHT ANGLE LIMIT CURVE

500 KNOTS RELEASE VELOCITY
4.0g PULLOUT

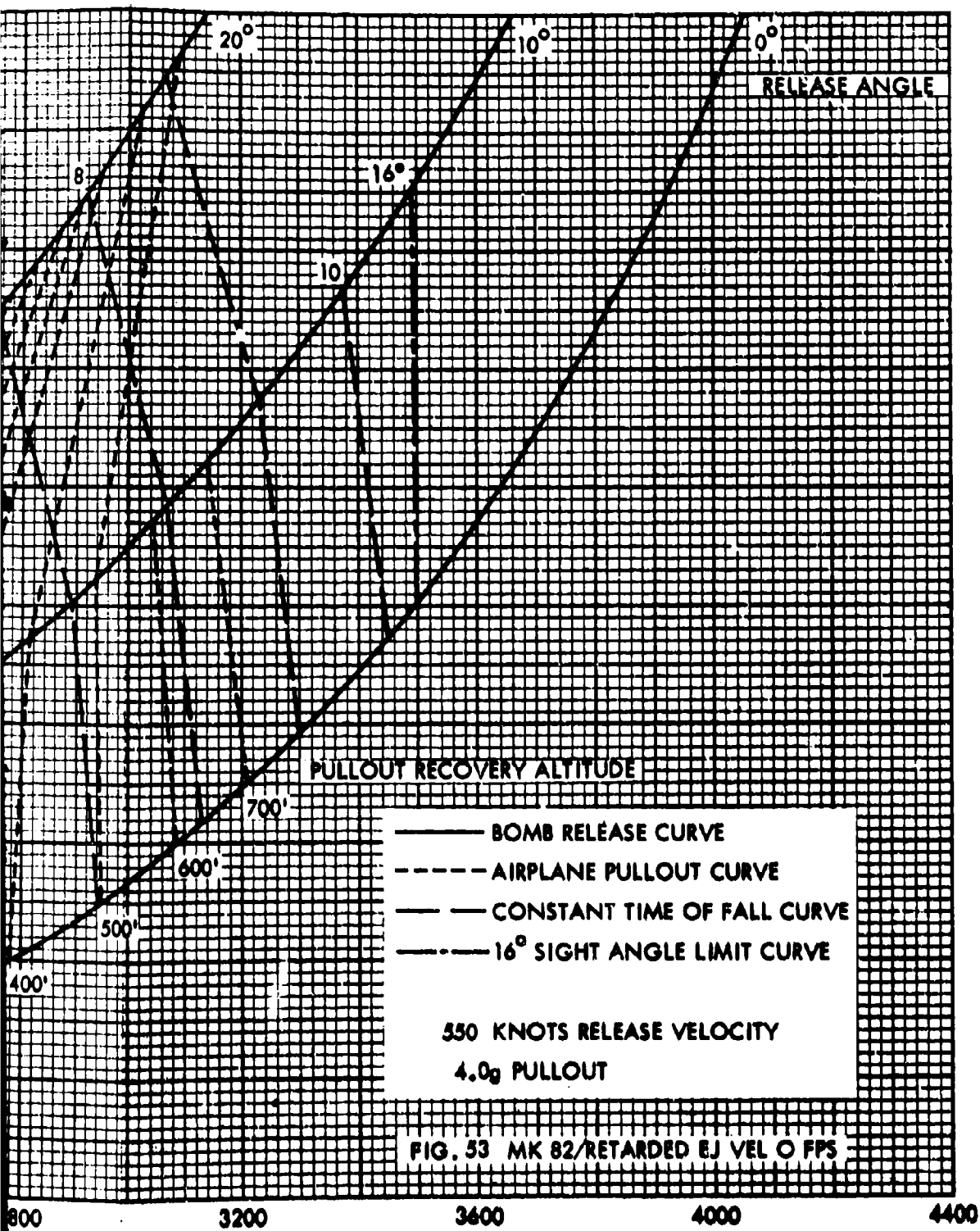
FIG. 52 MK 82/RETARDED EJ VEL O FPS

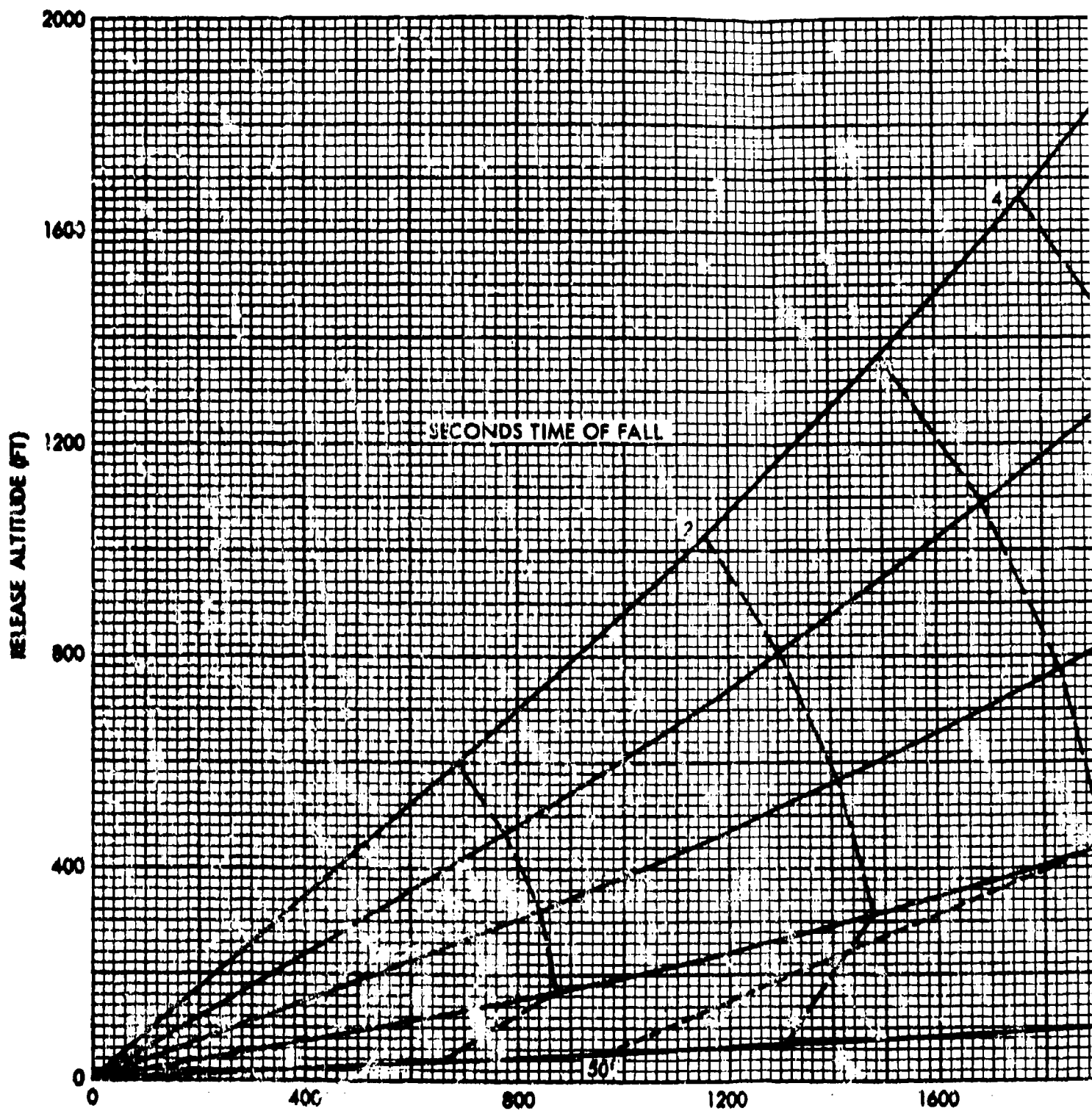
3

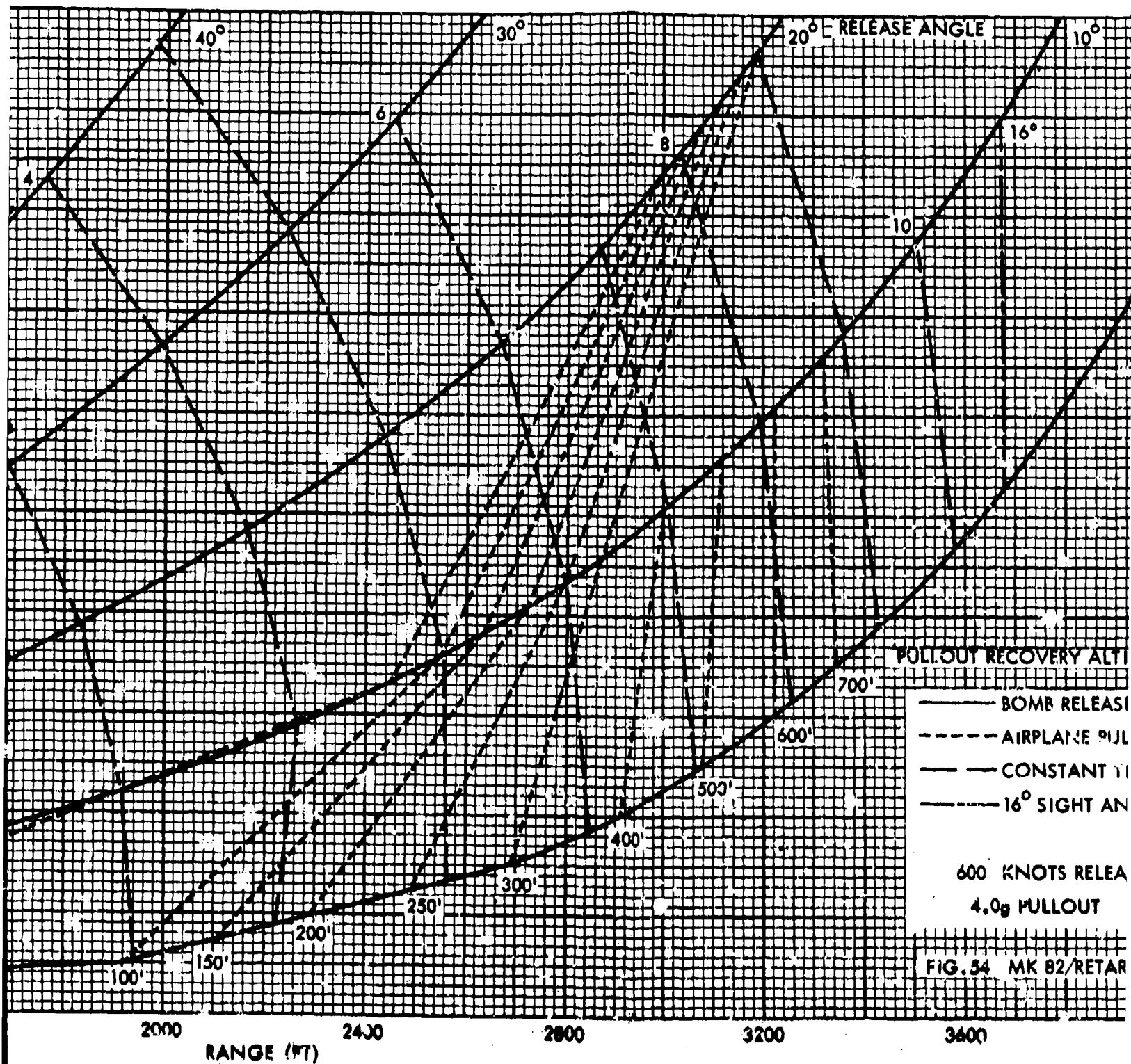




2







2

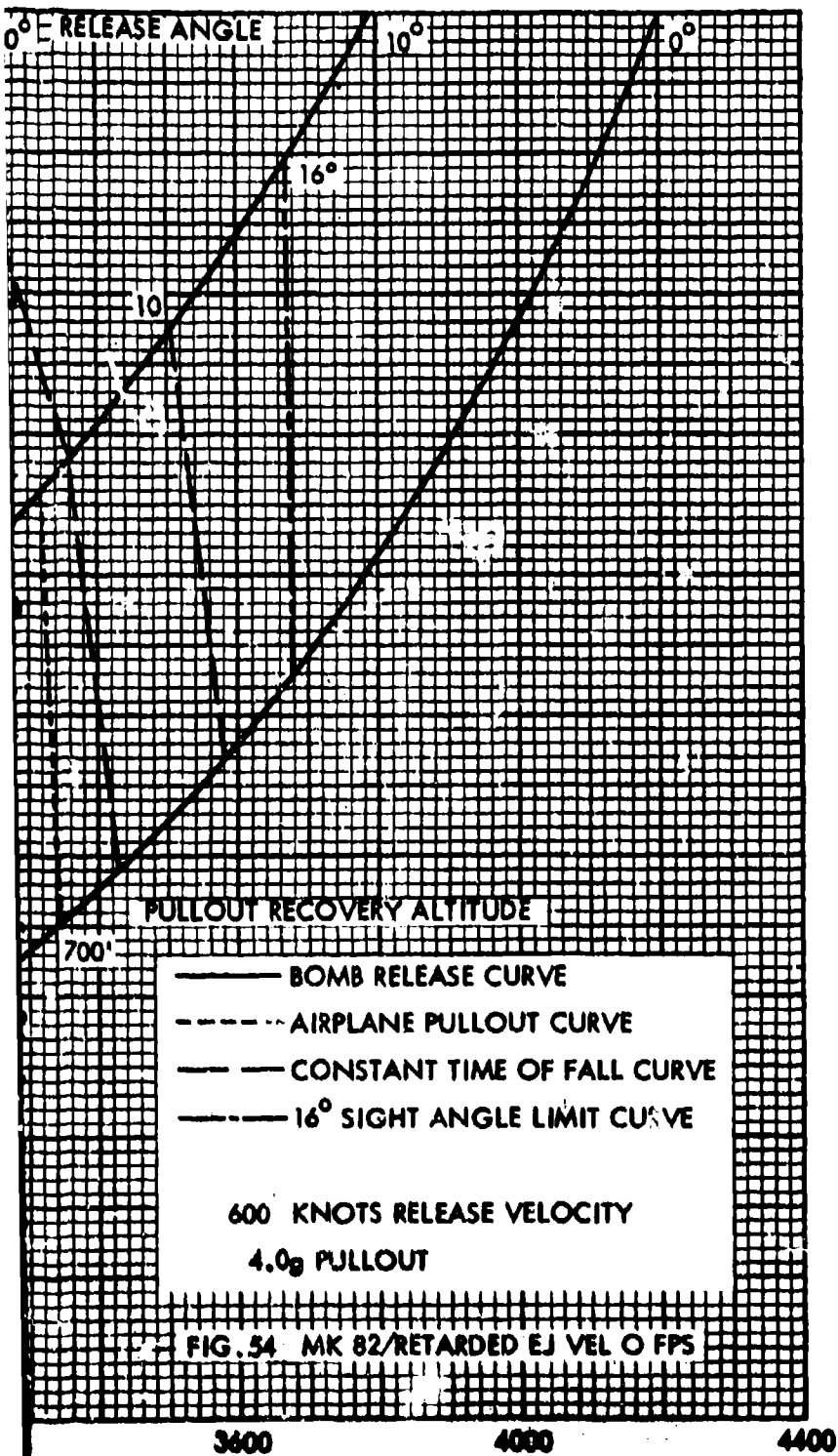


FIG. 54 MK 82/RETARDED EJ VEL 0 FPS

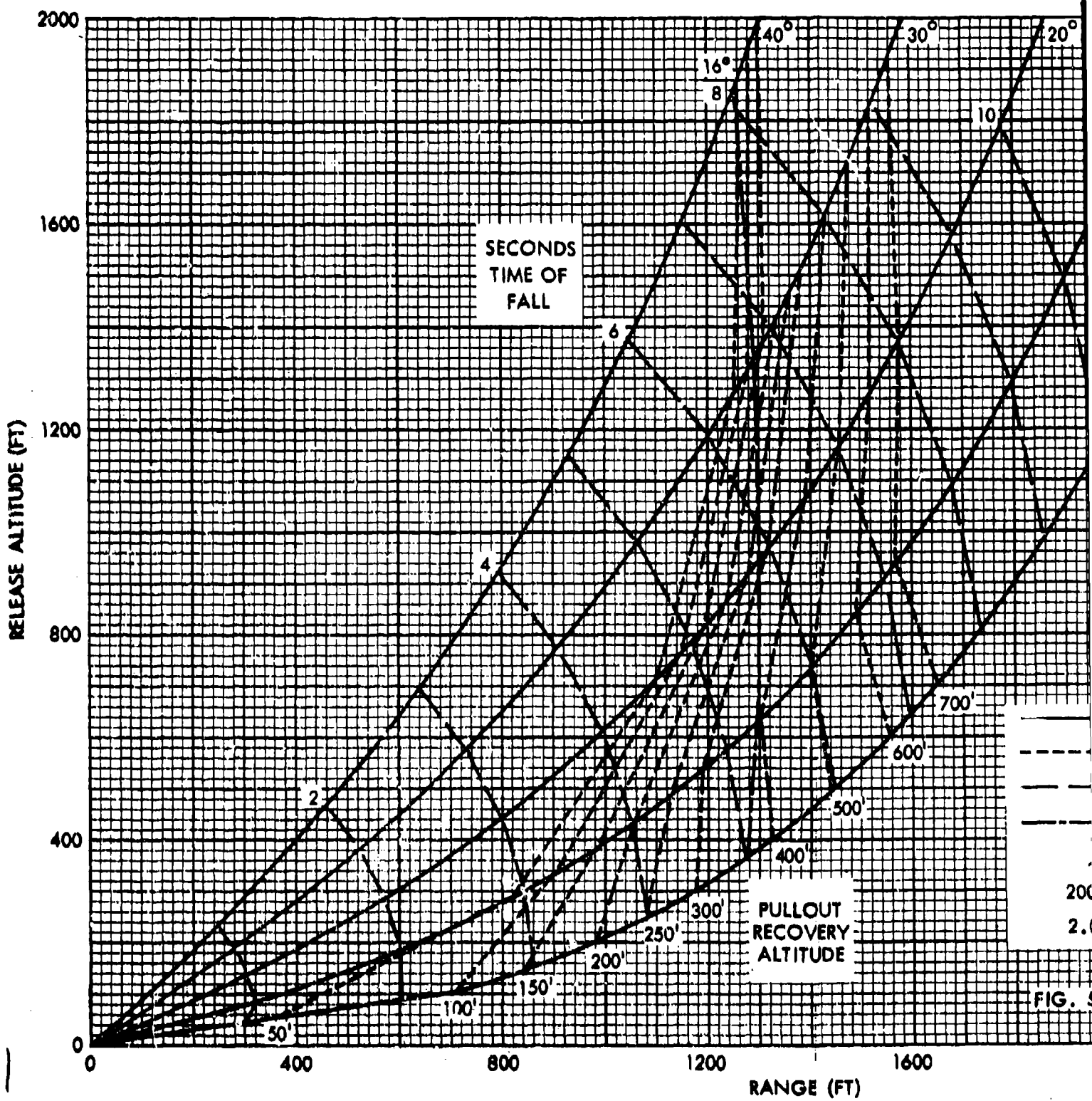
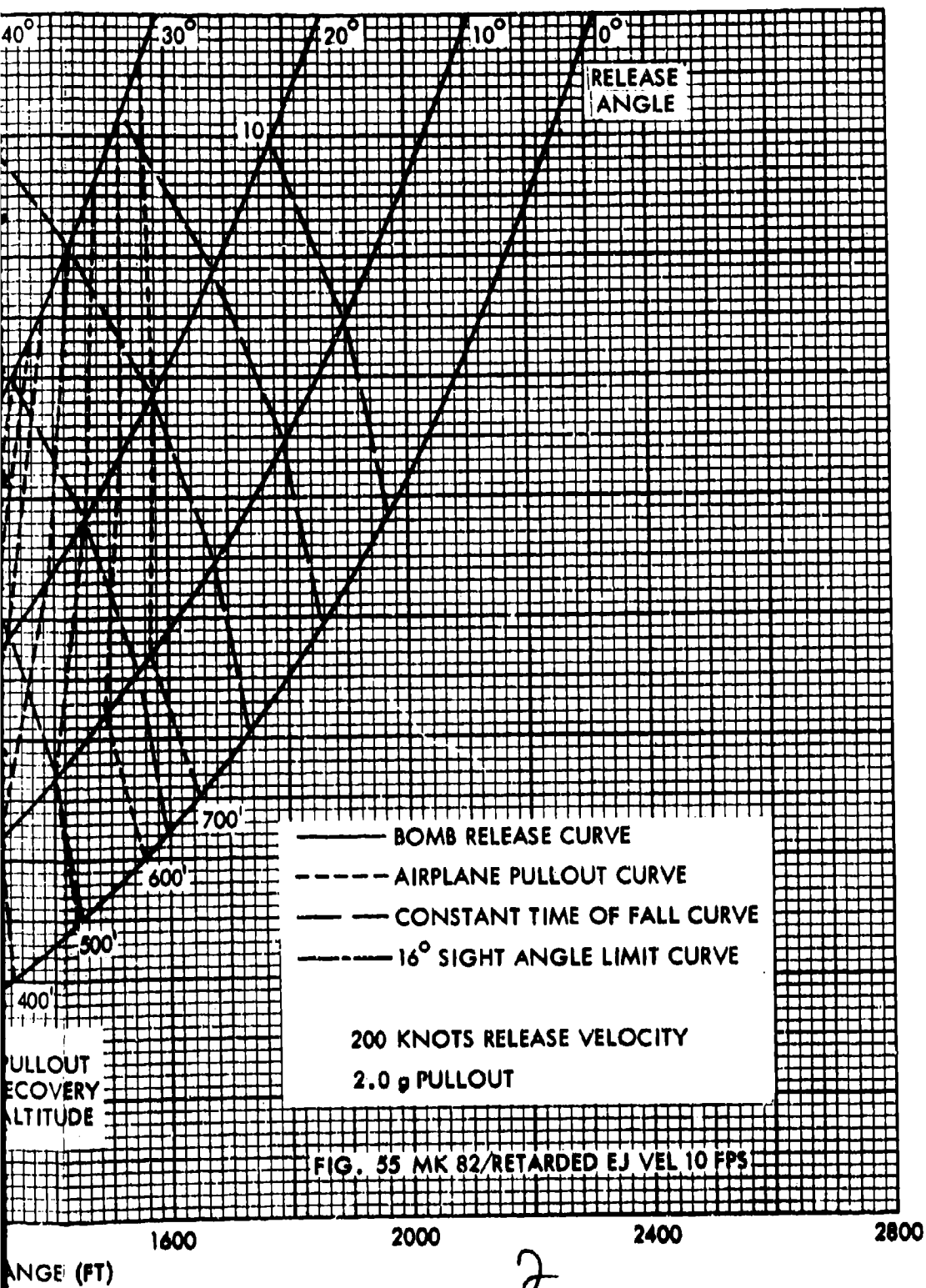
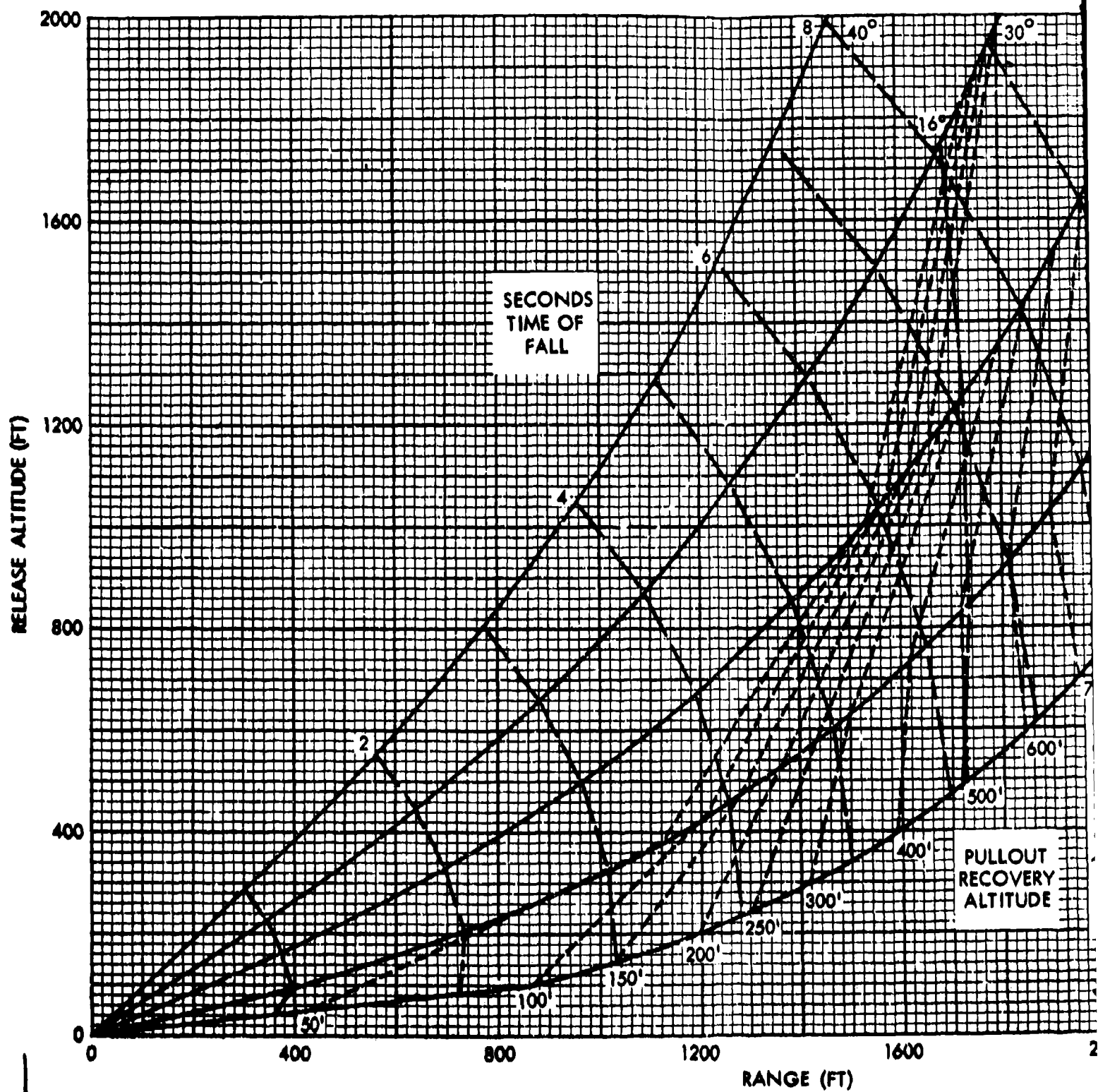
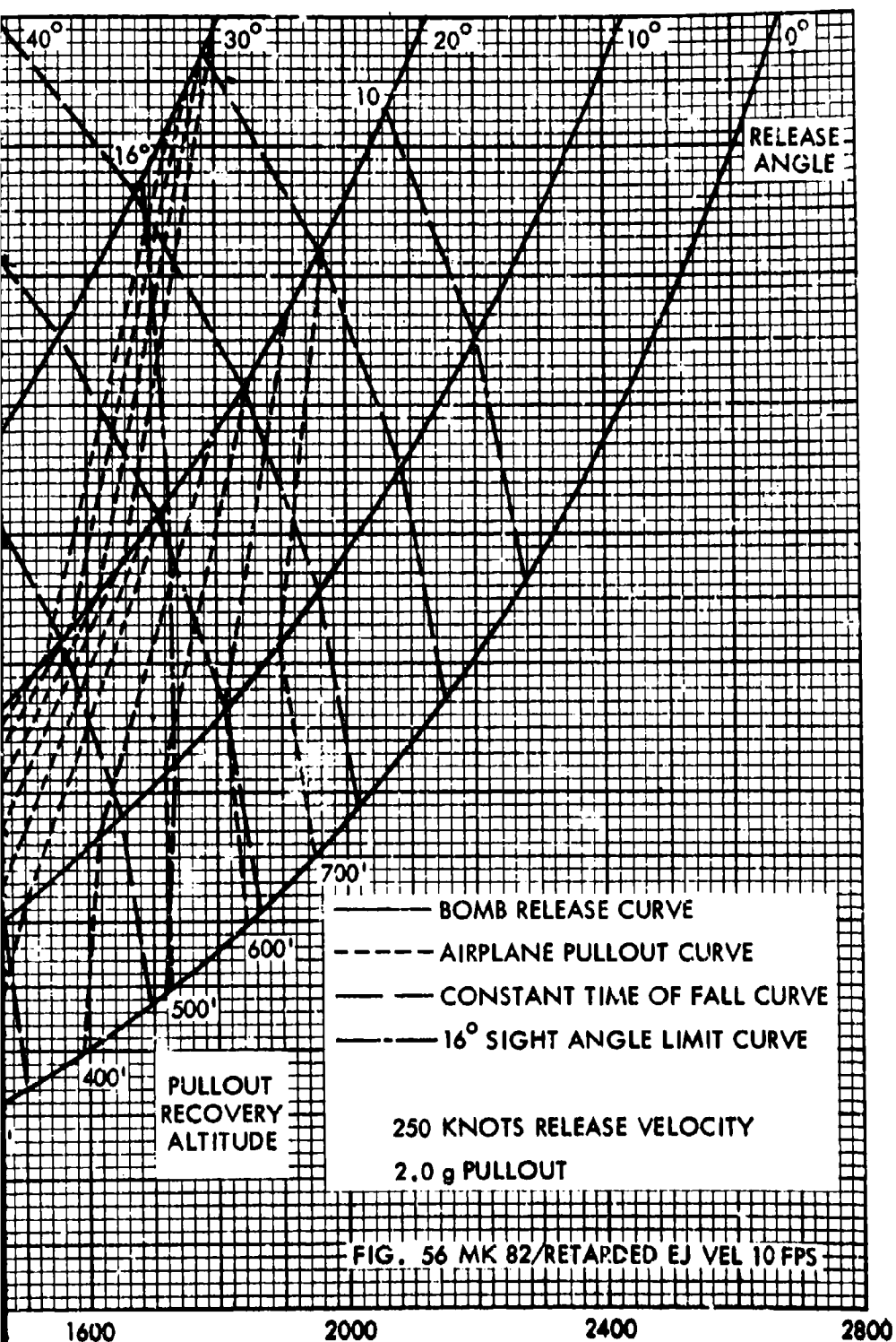


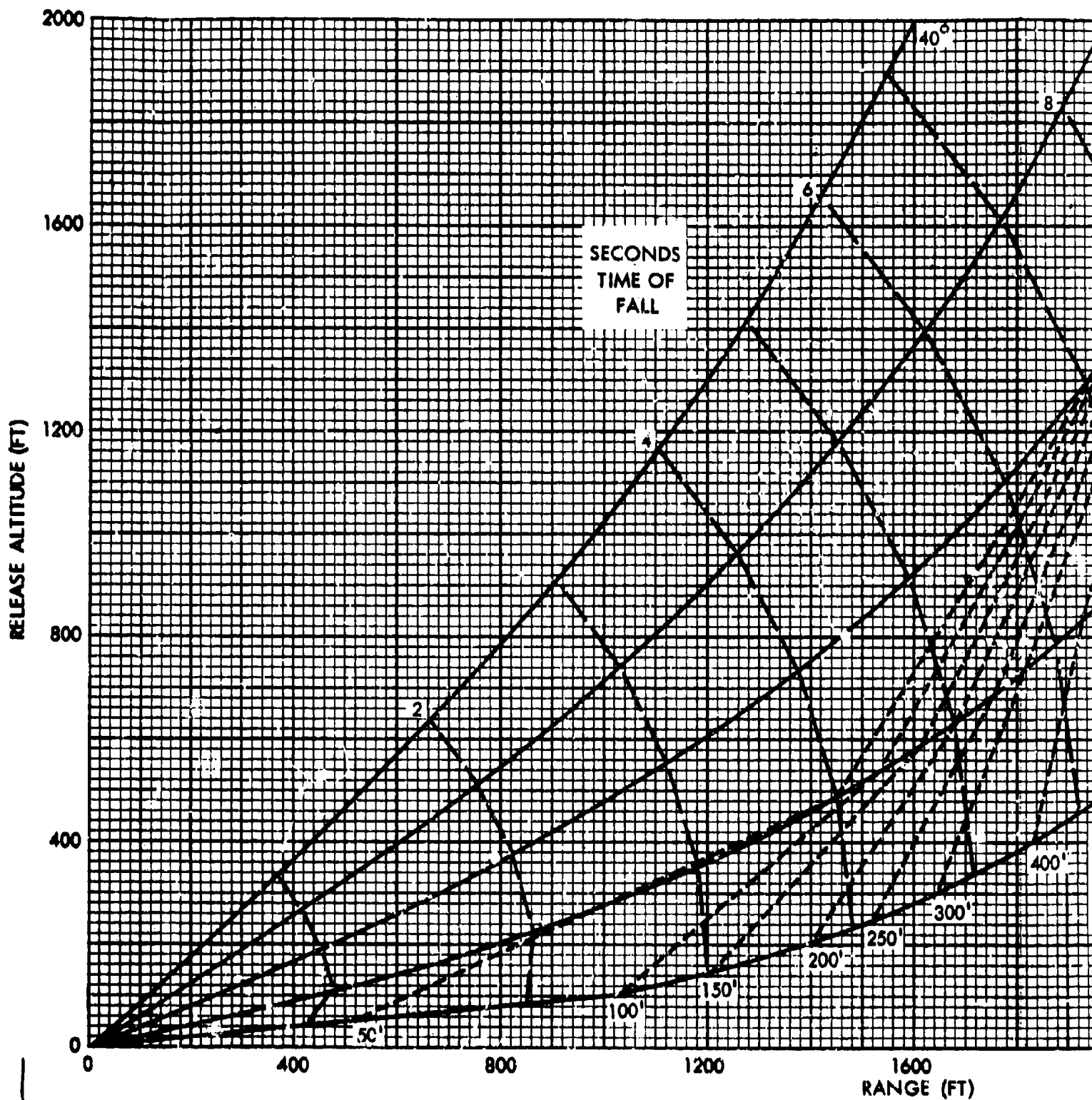
FIG. 5

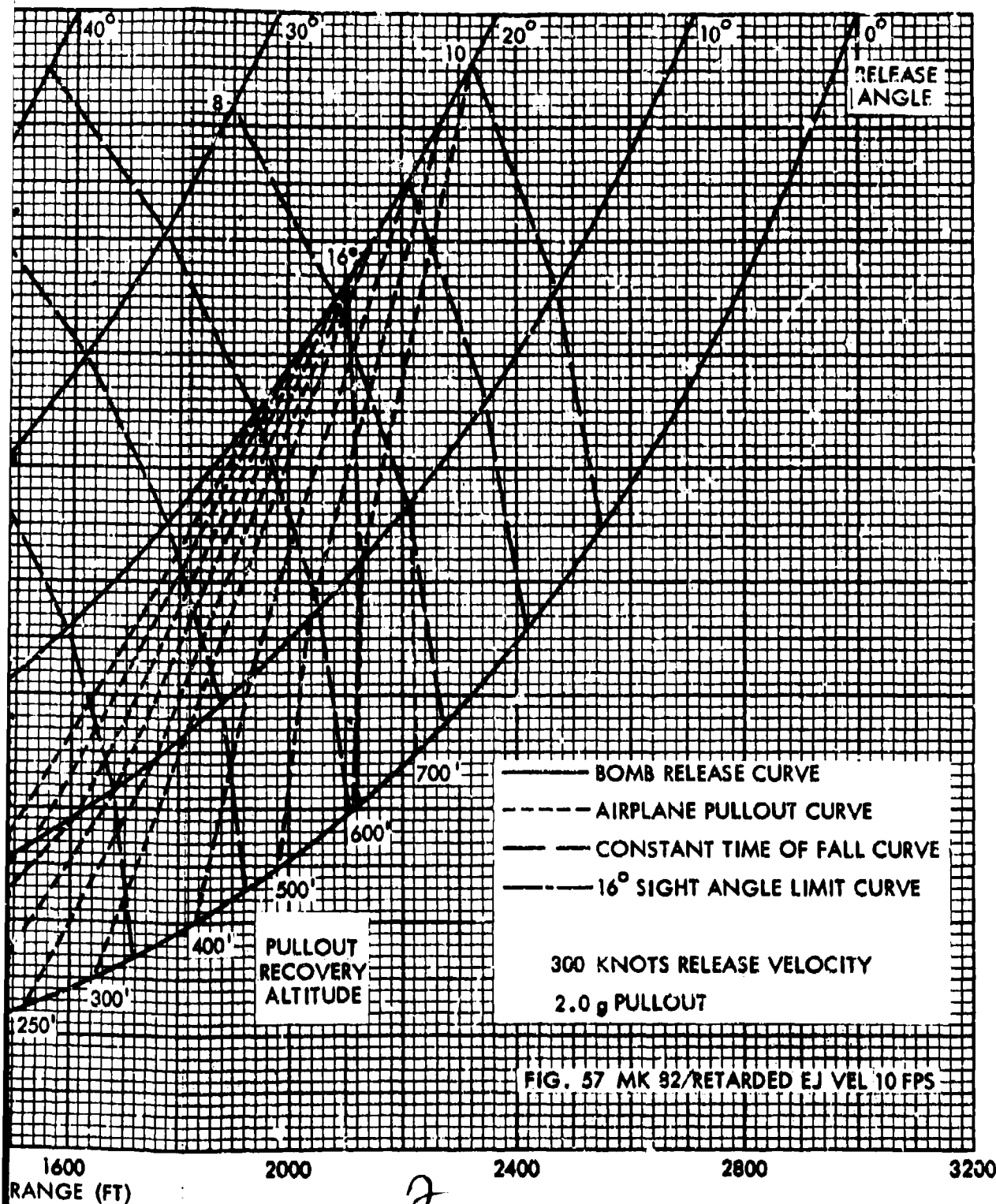


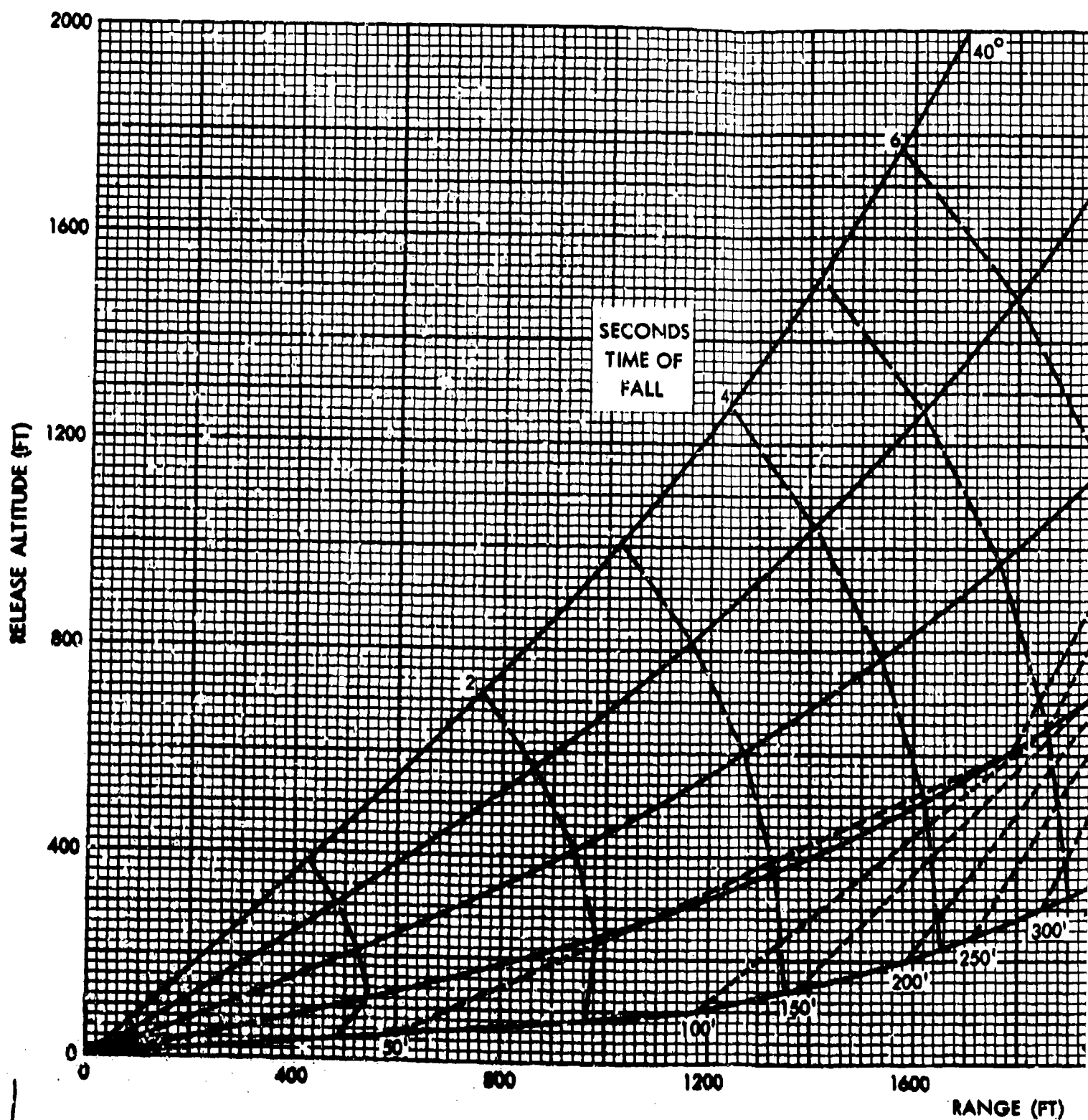




2







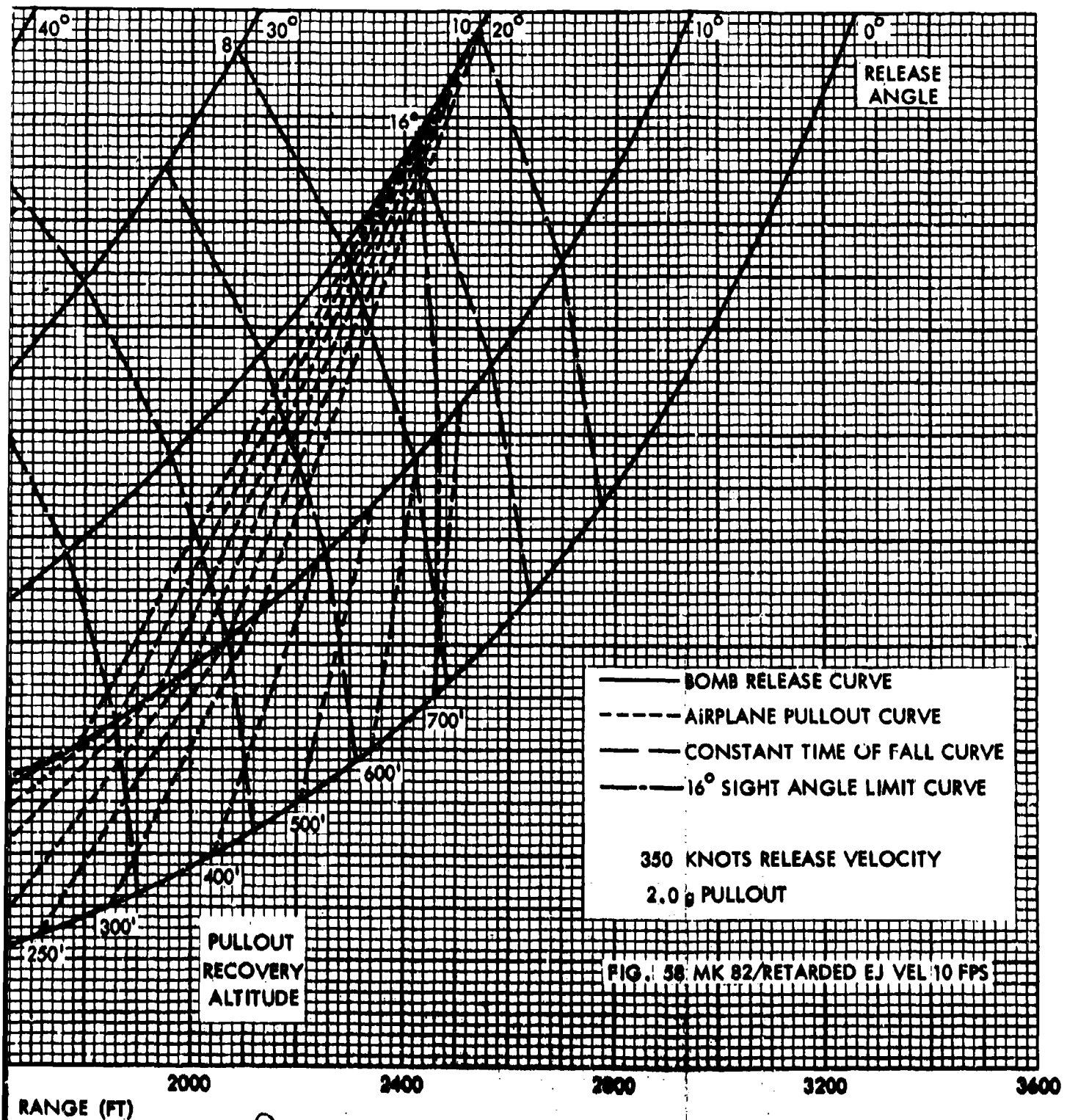
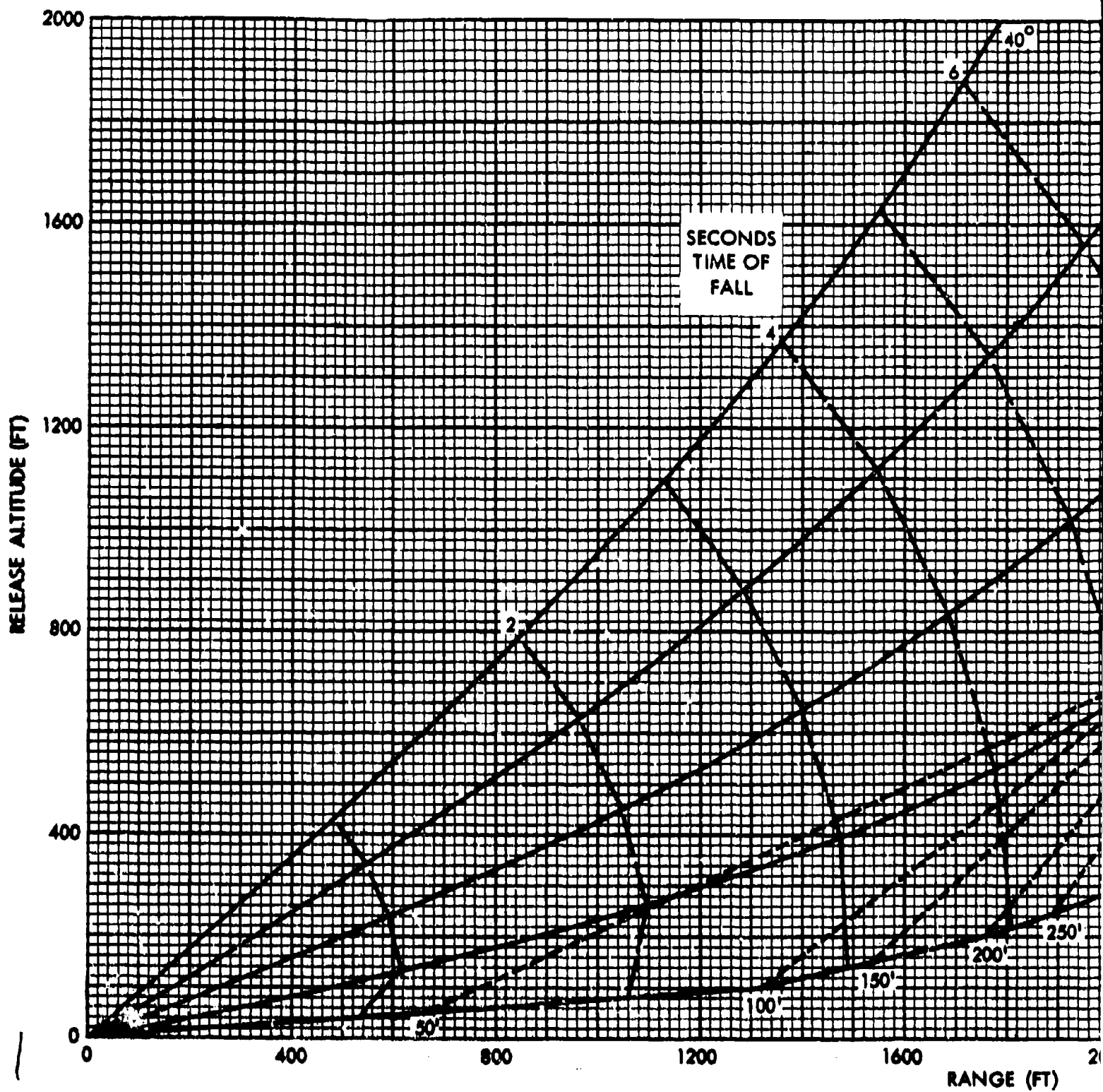
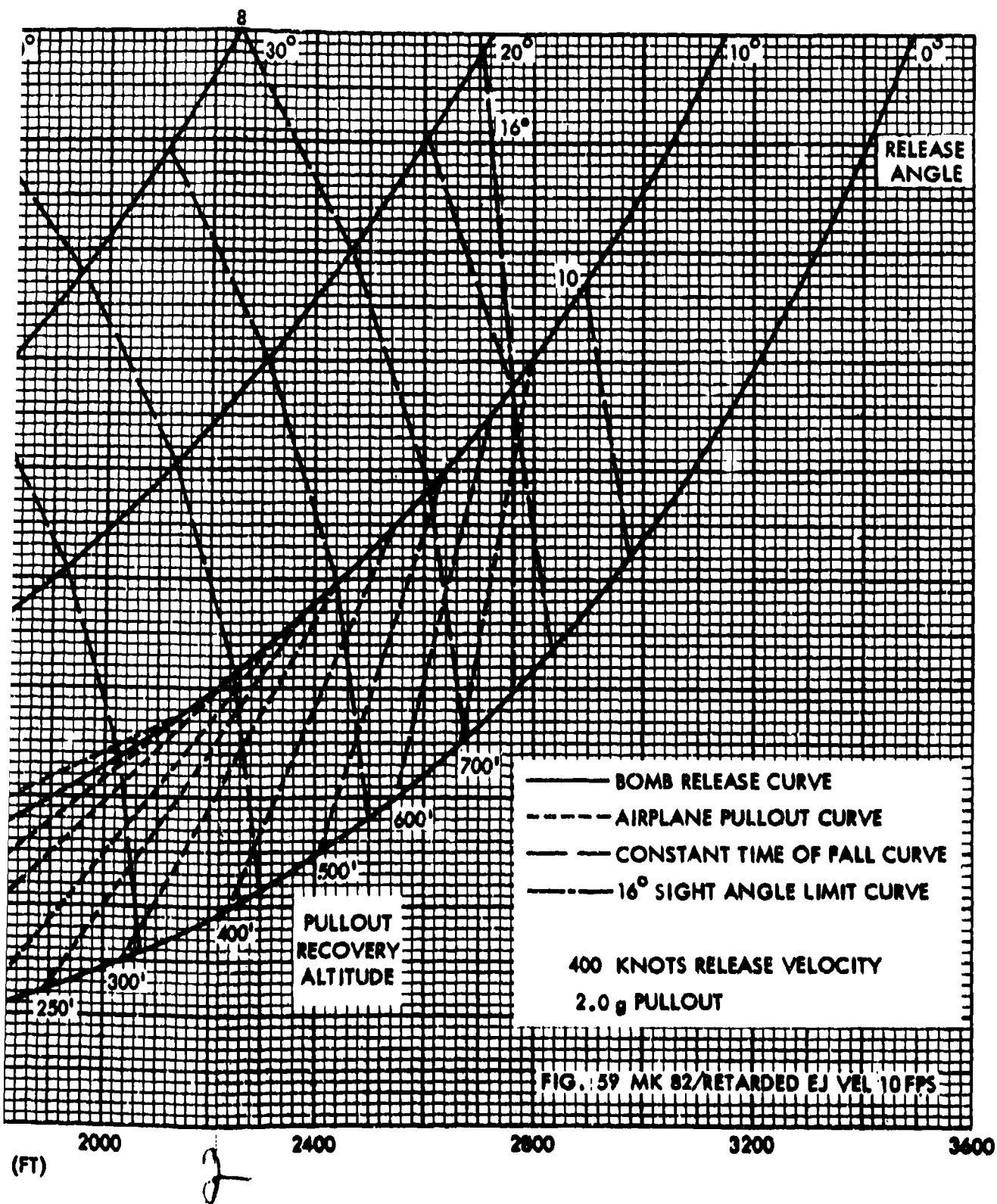
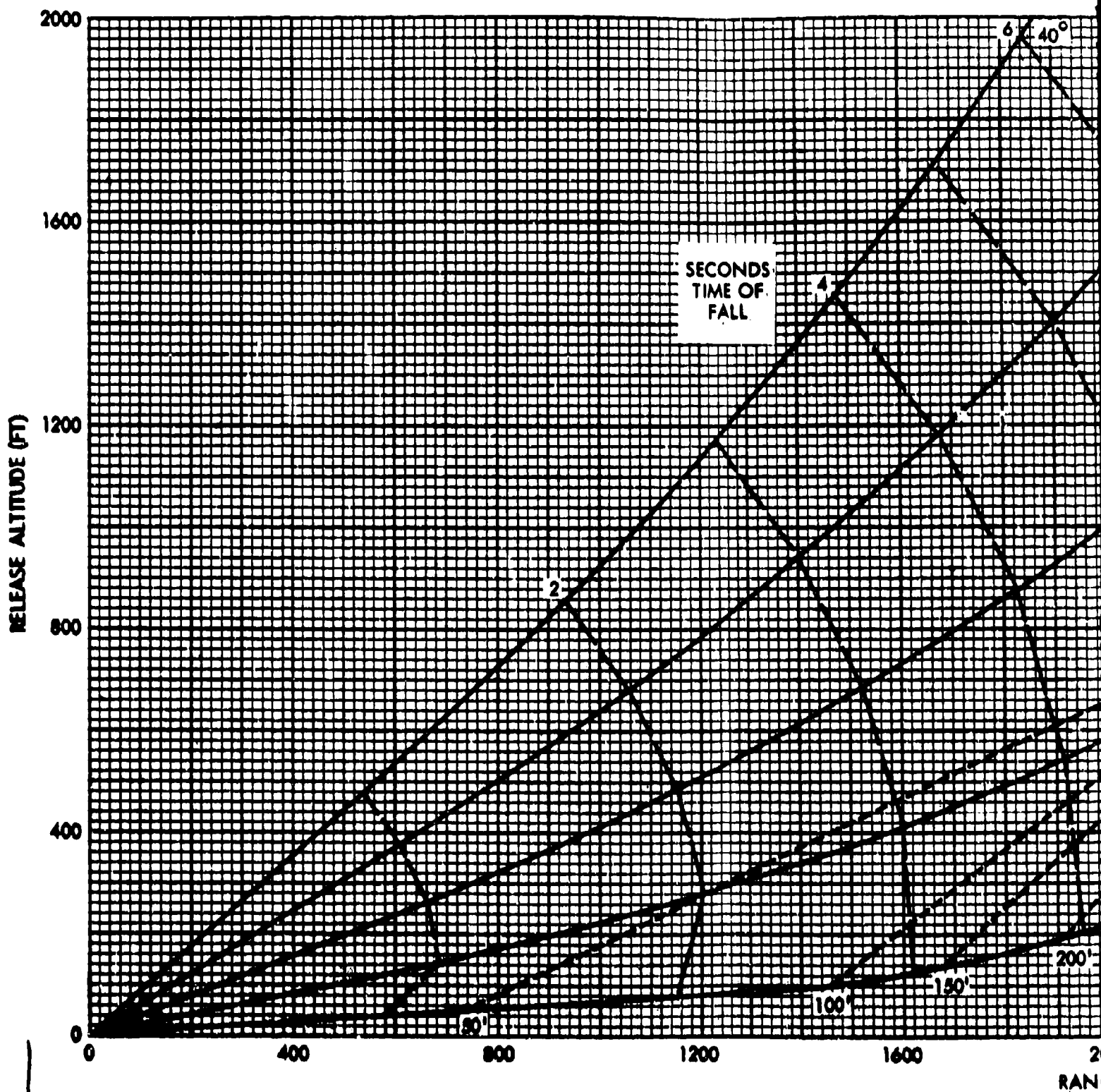
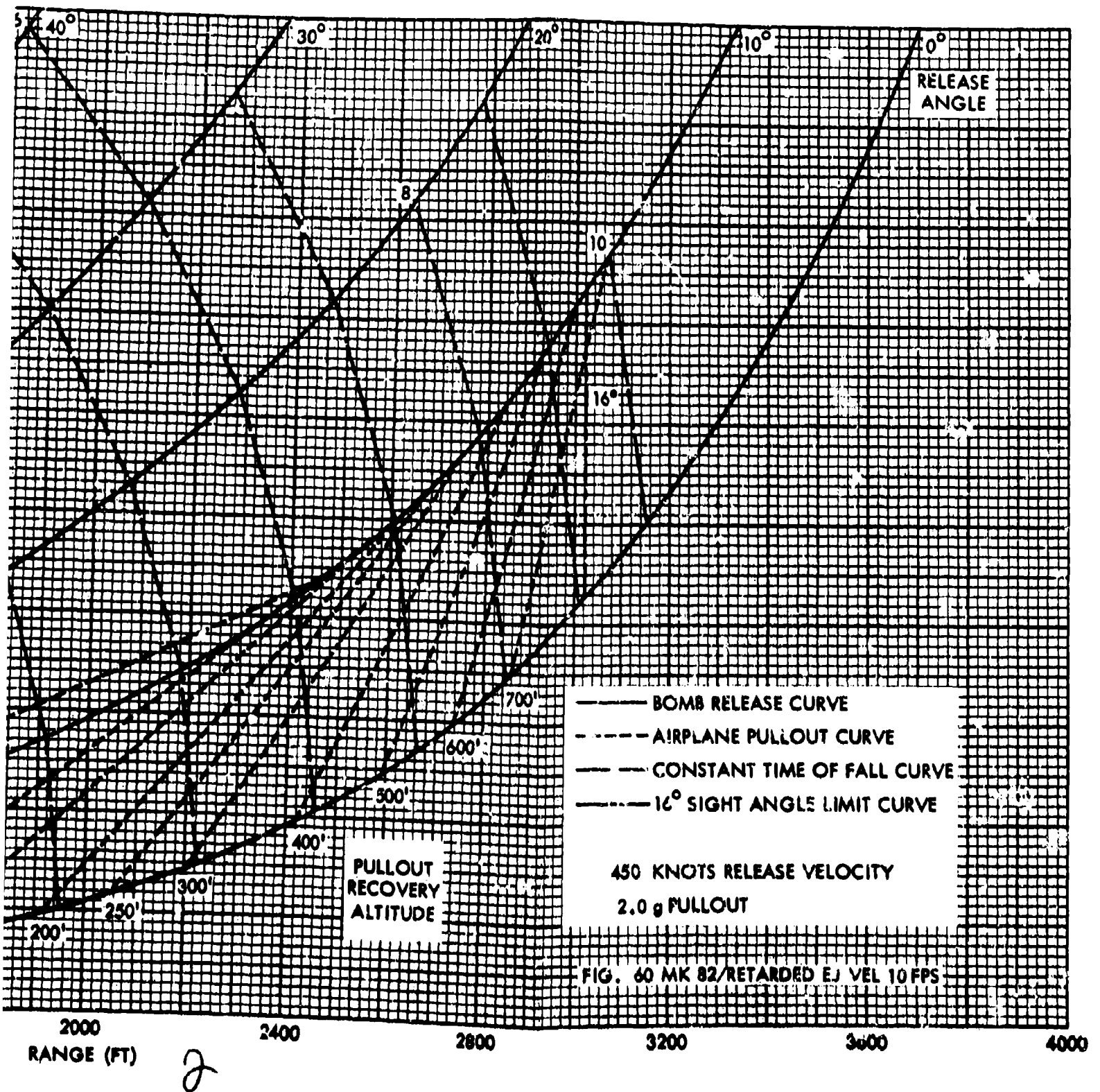


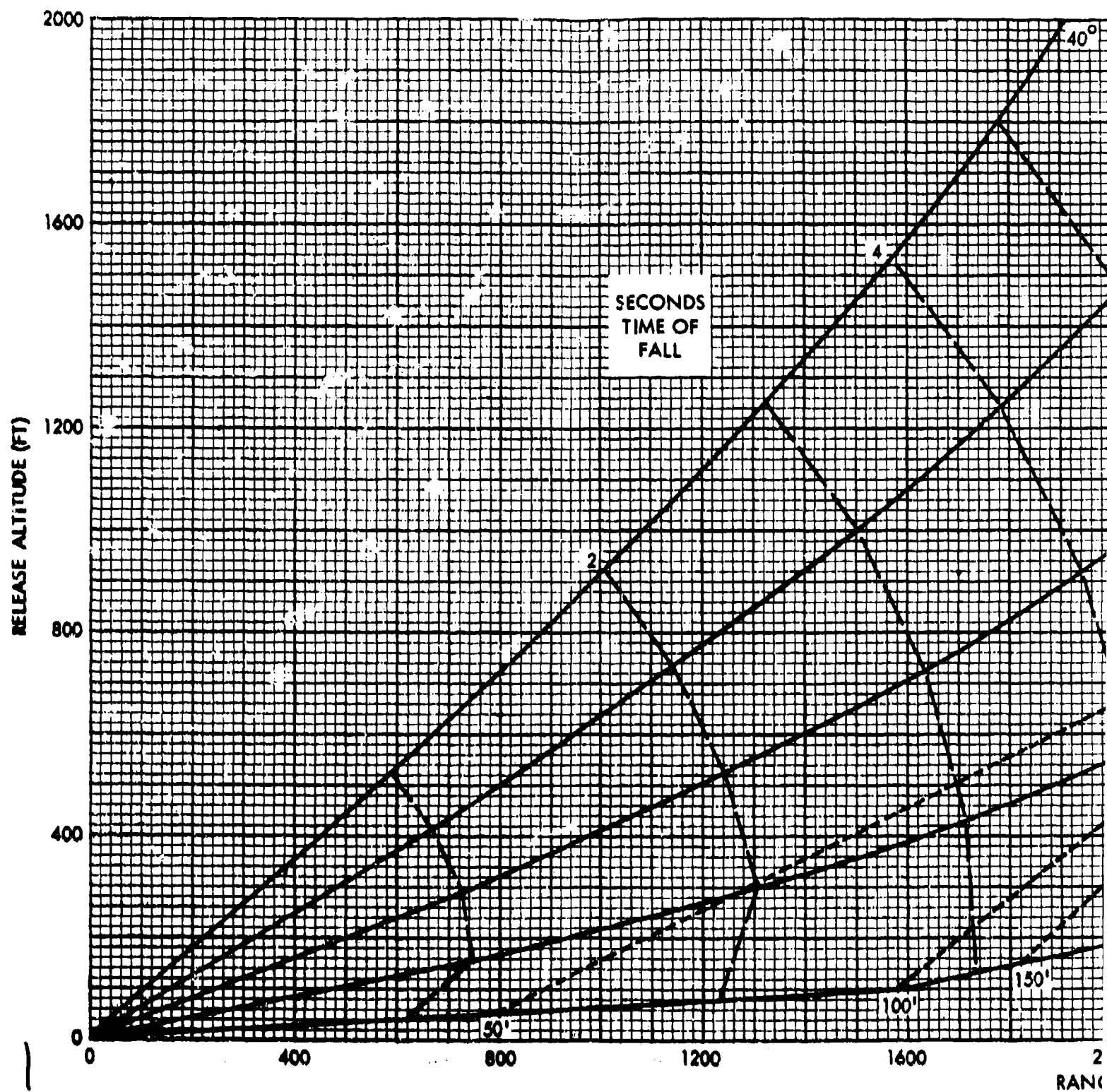
FIG. 58 MK 82/RETARDED EJ VEL 10 FPS

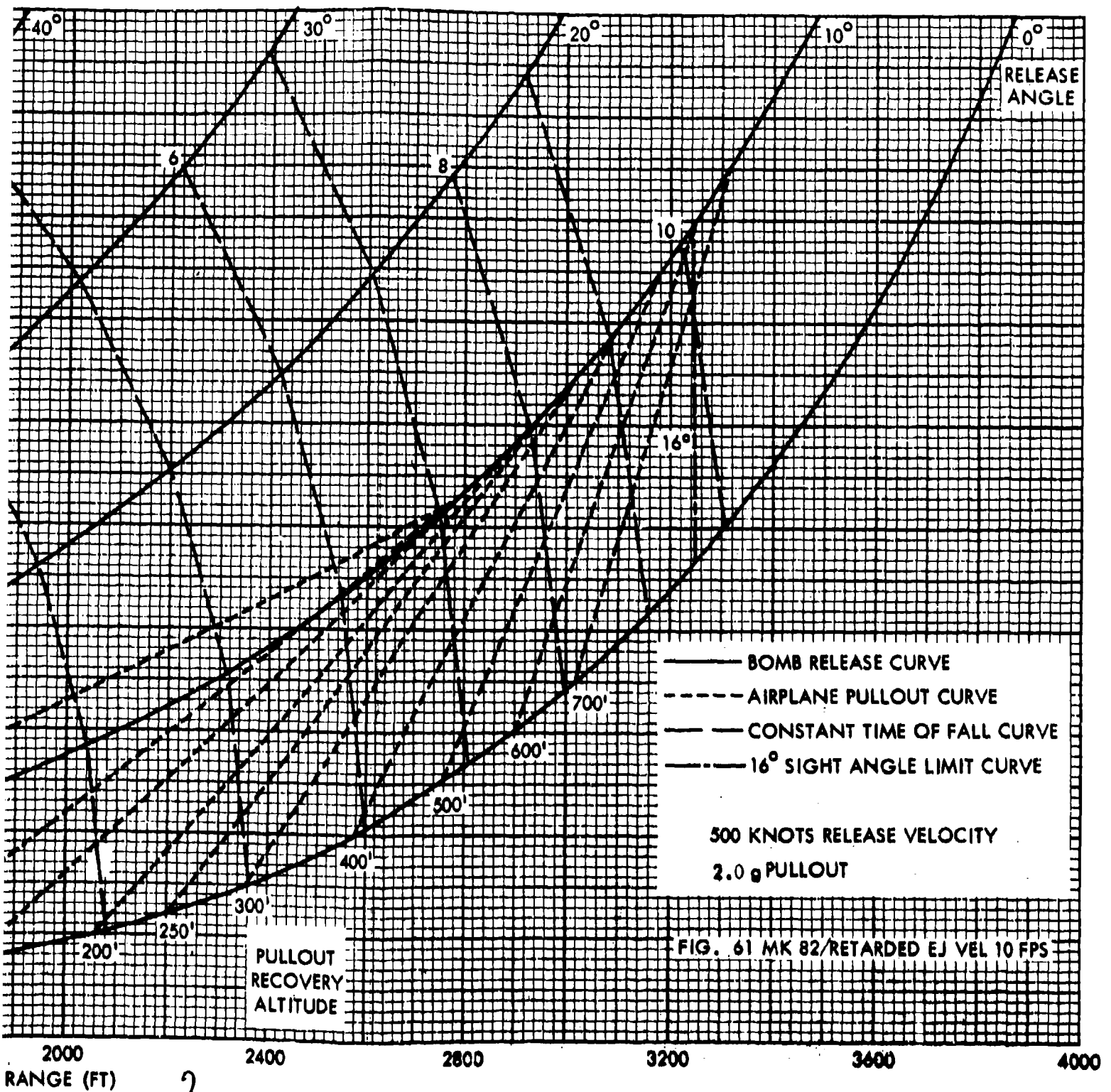


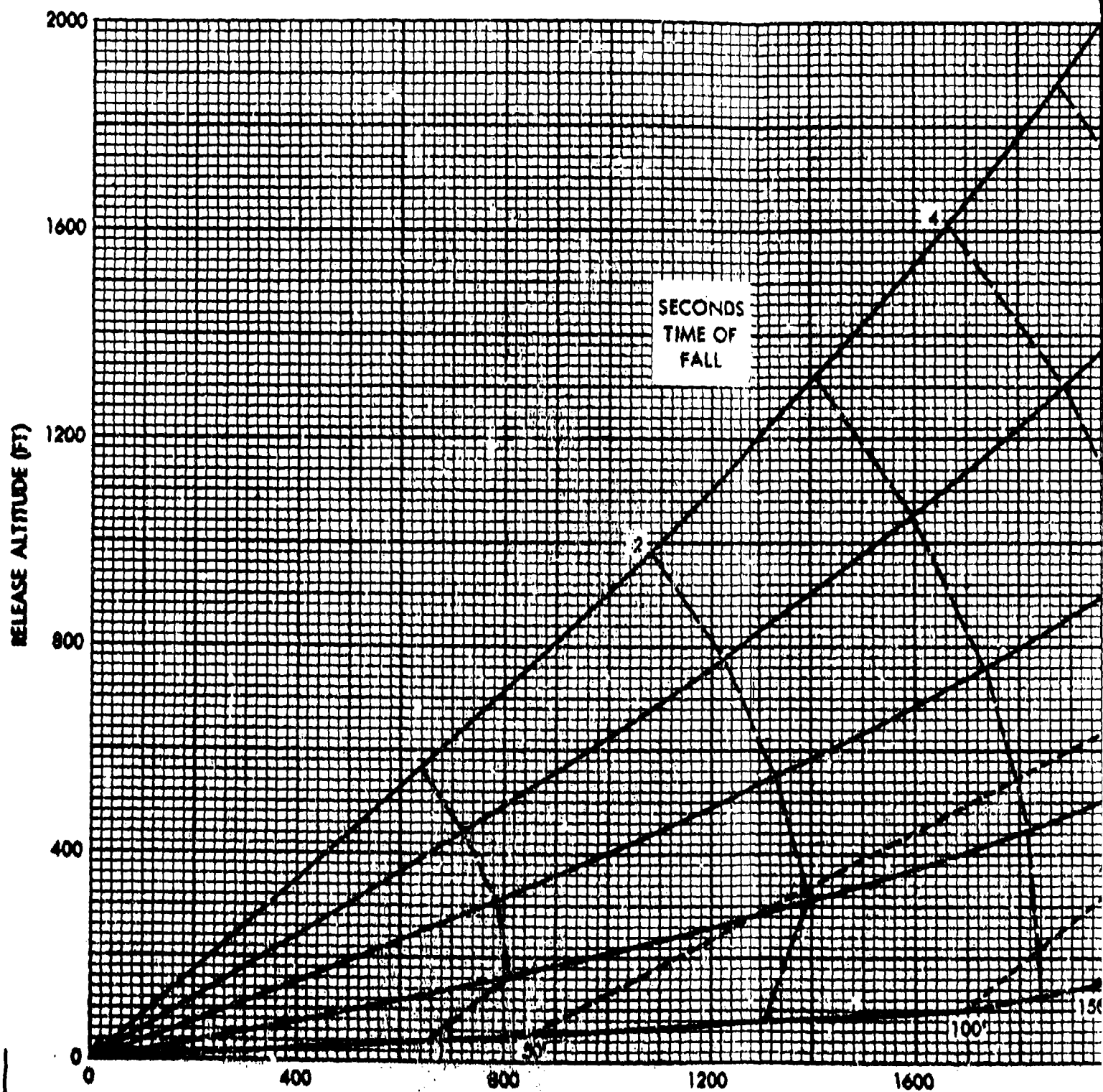


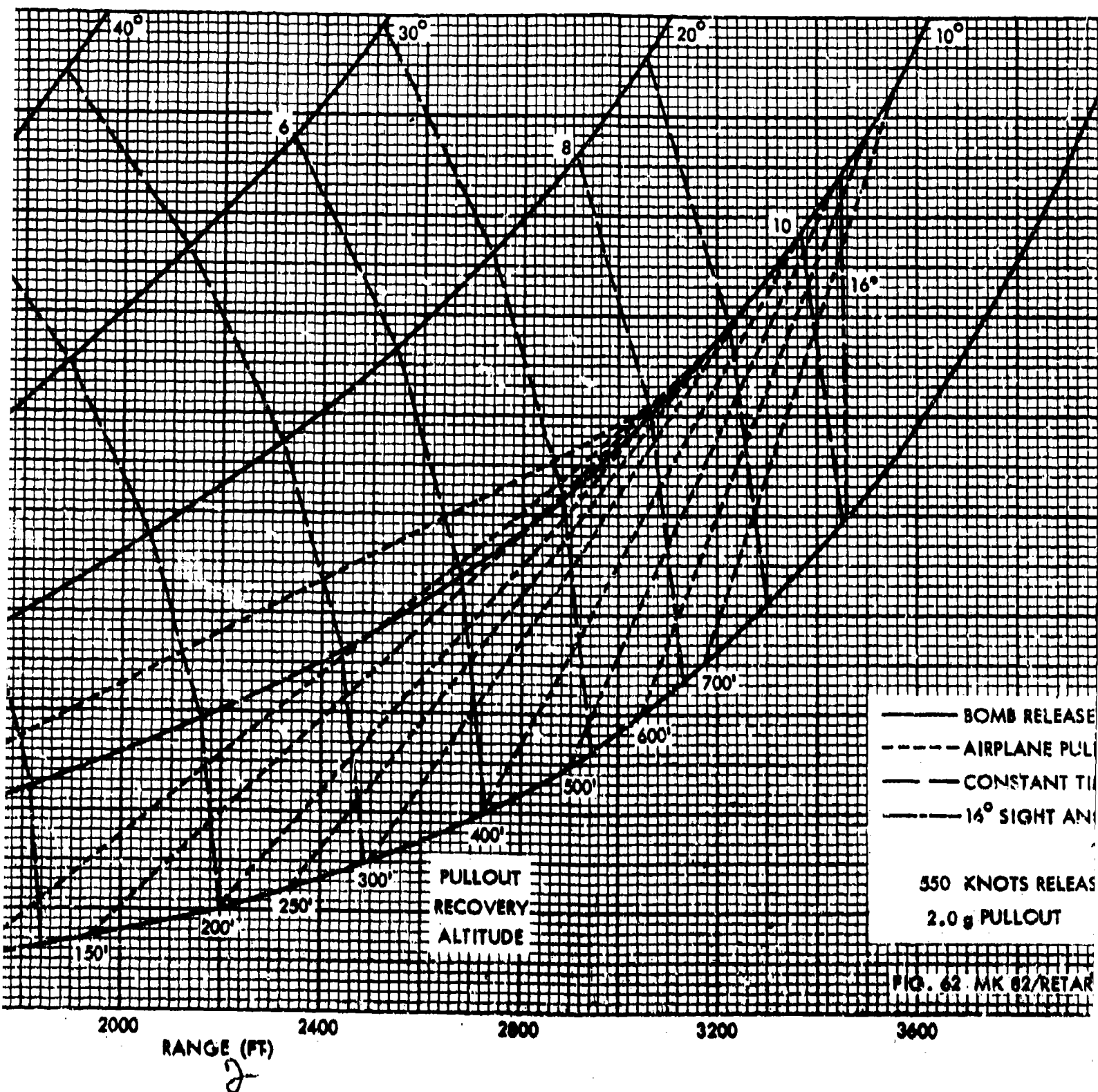


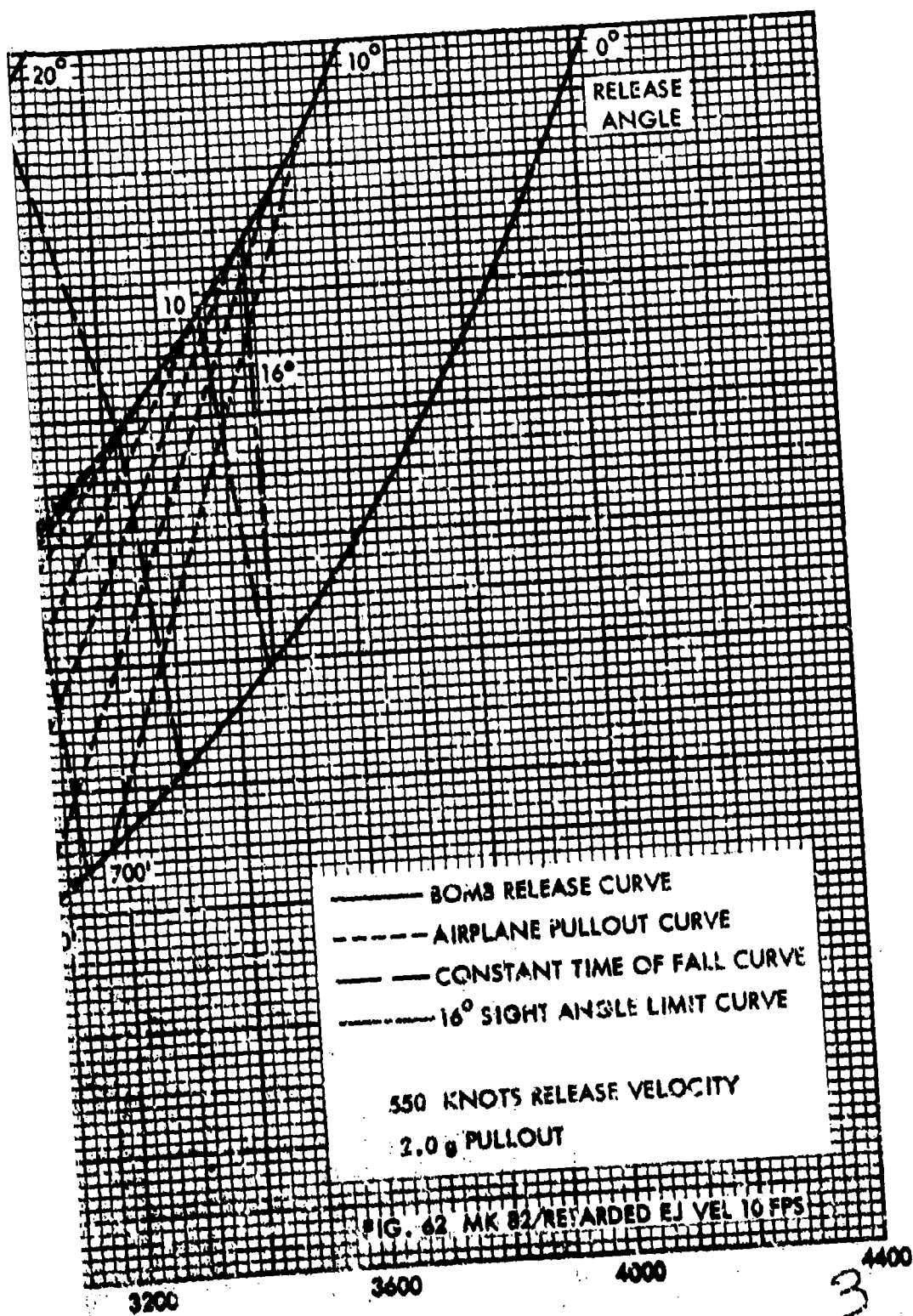


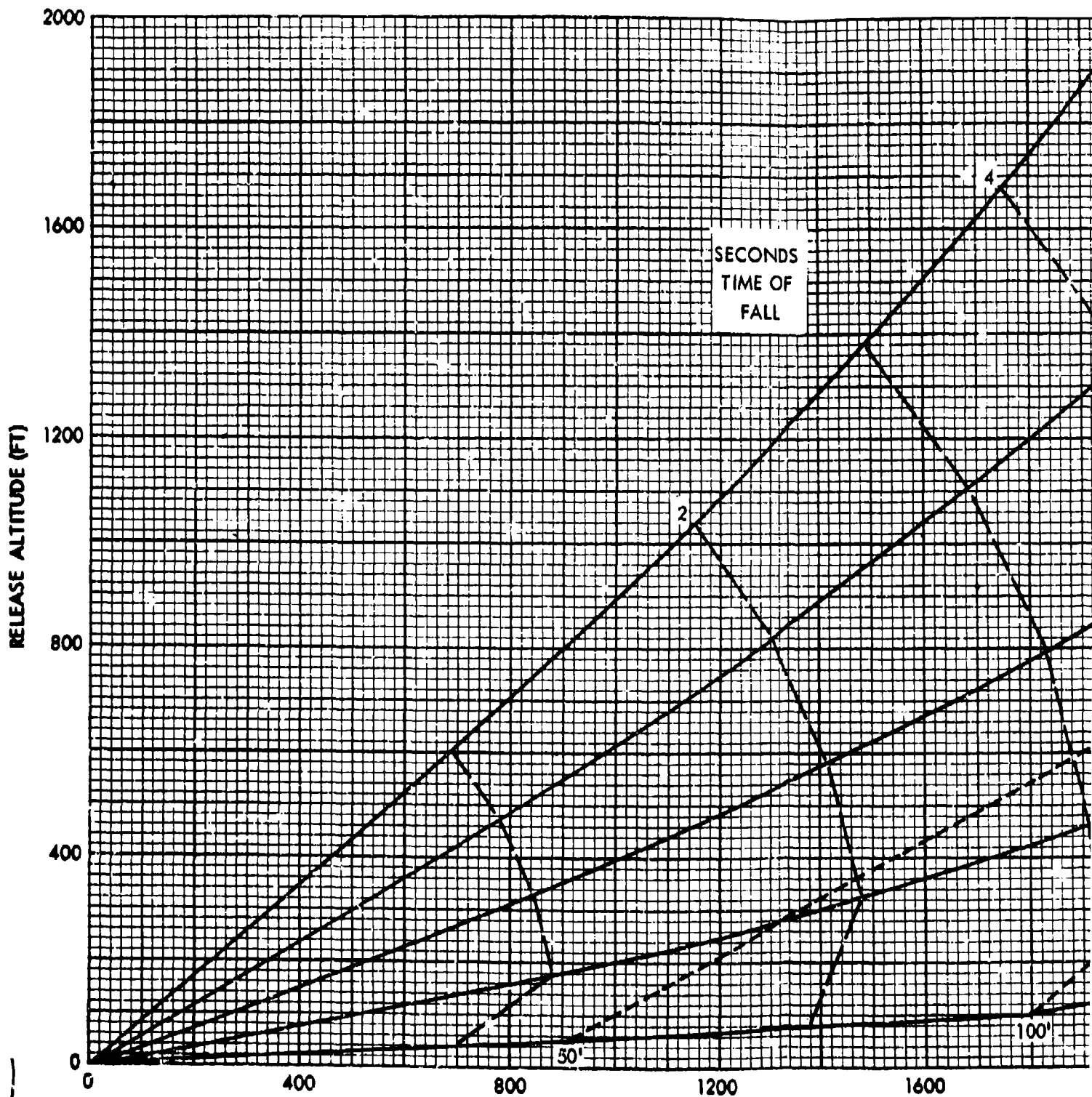


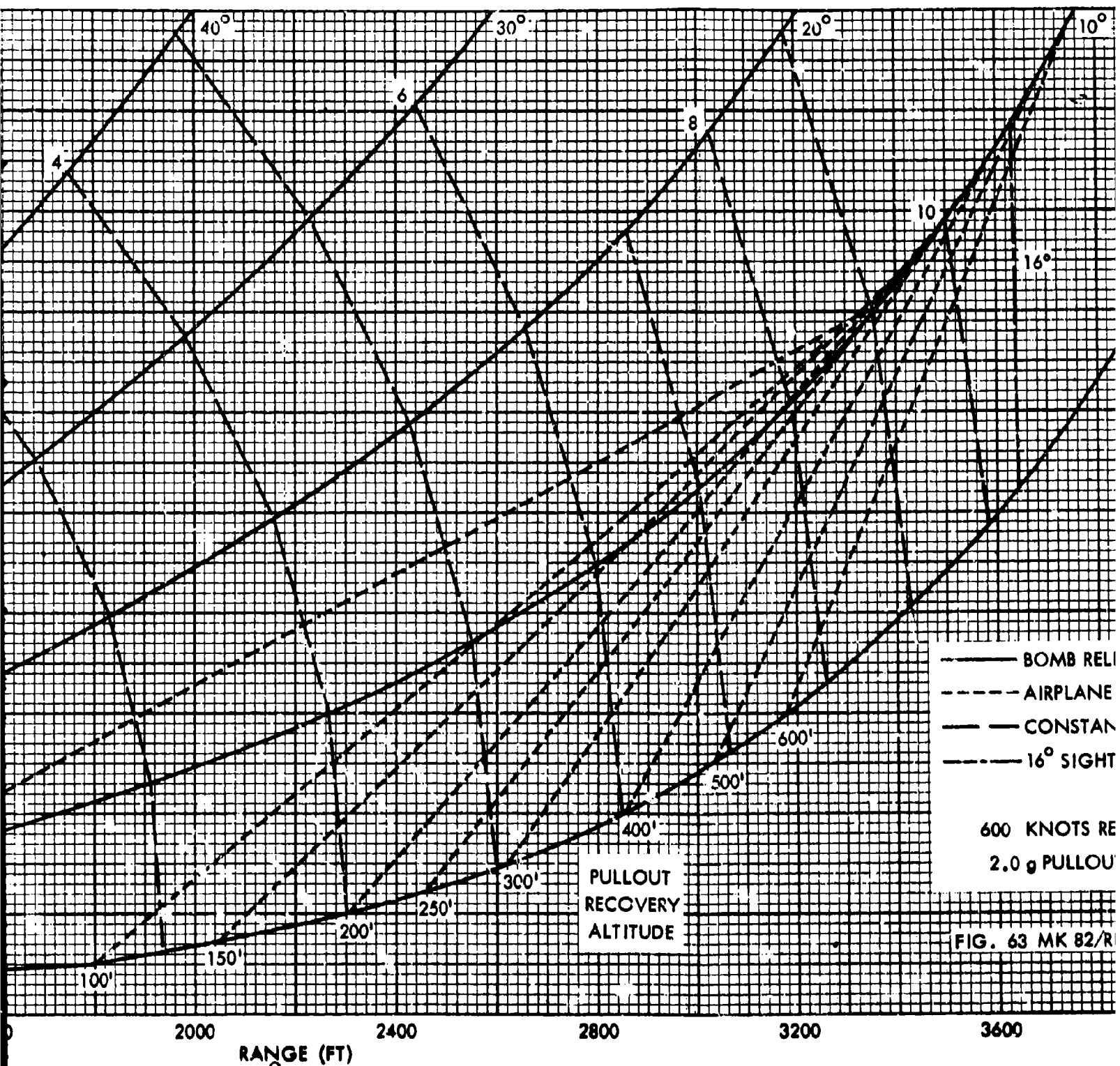


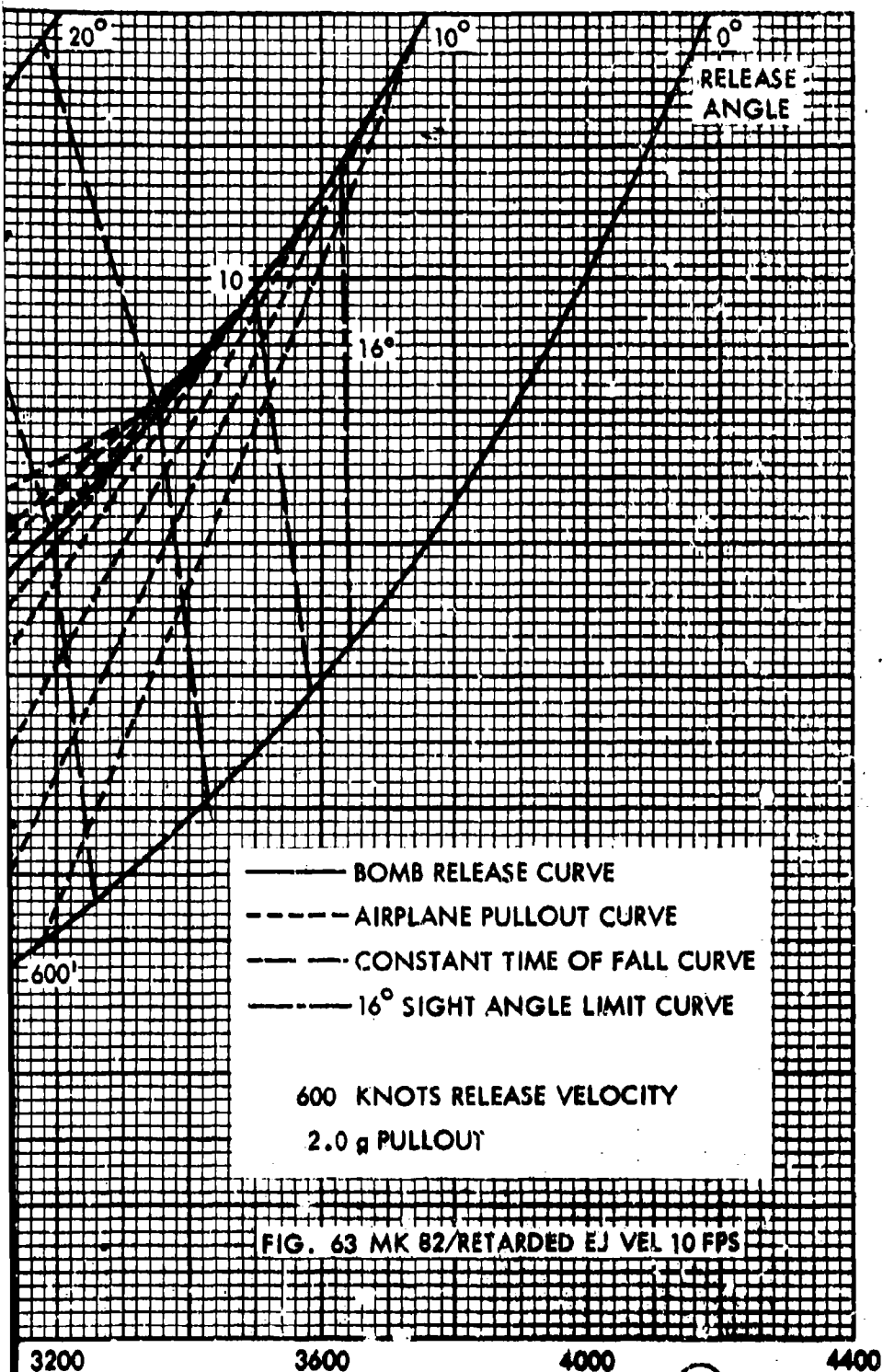


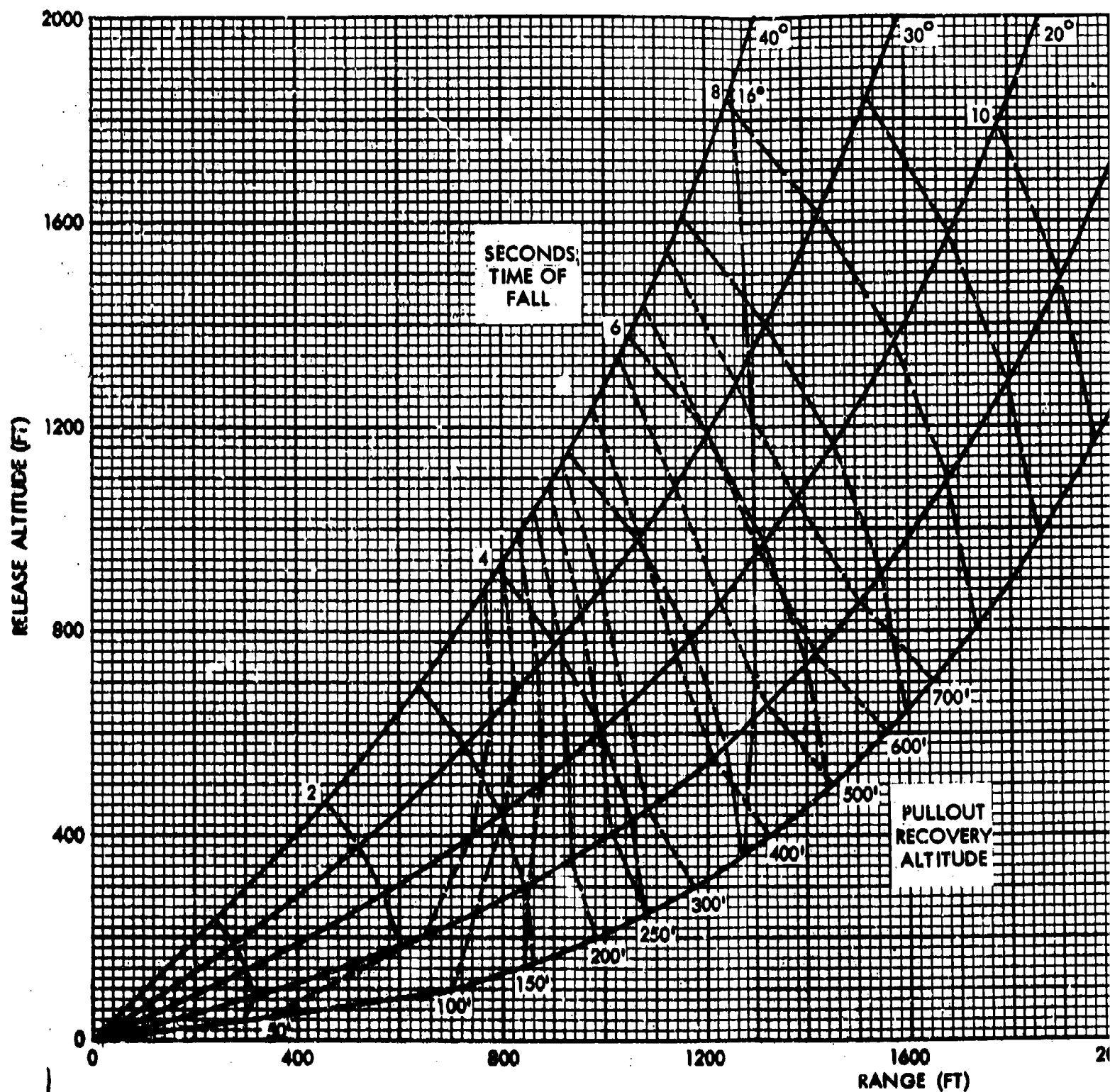




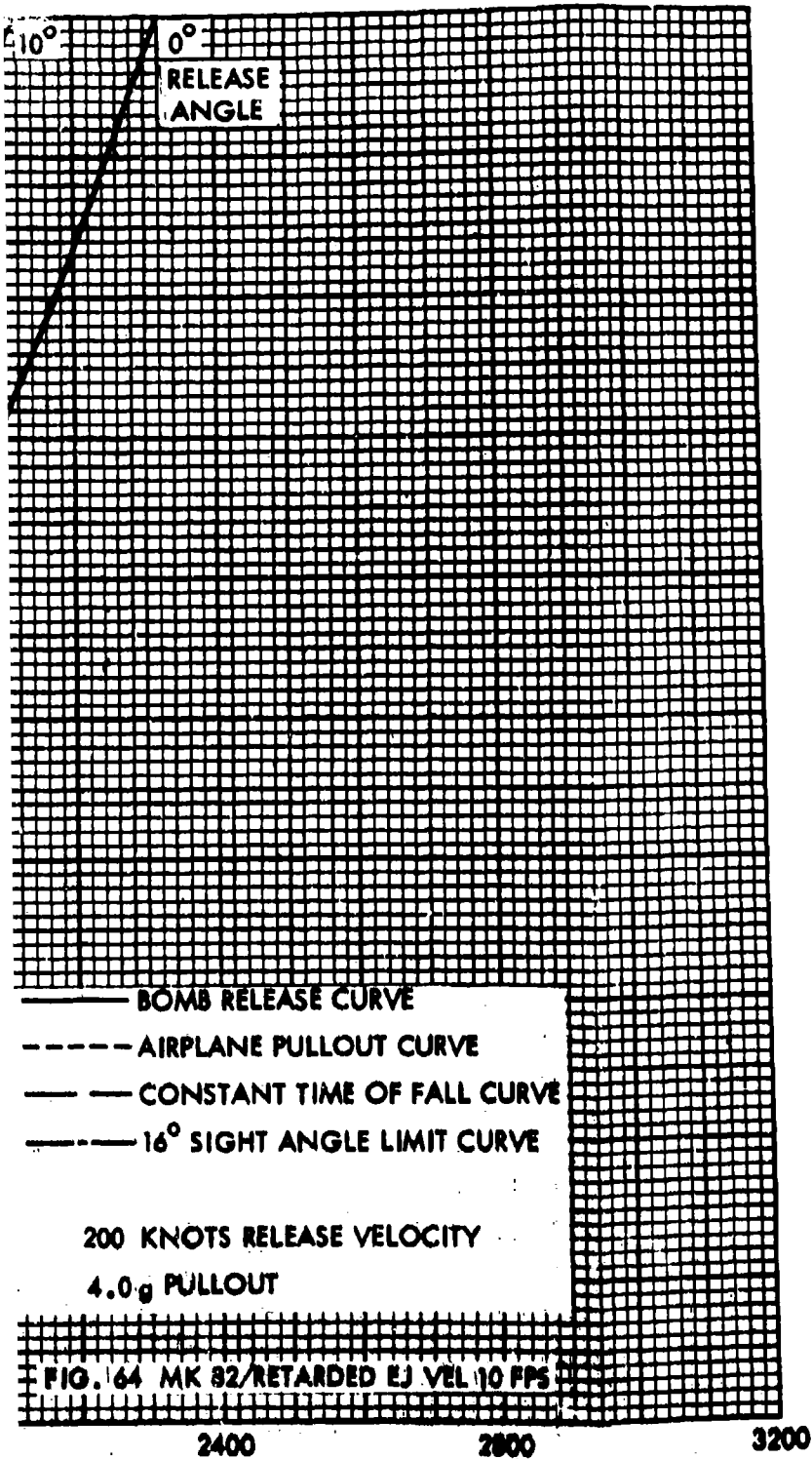




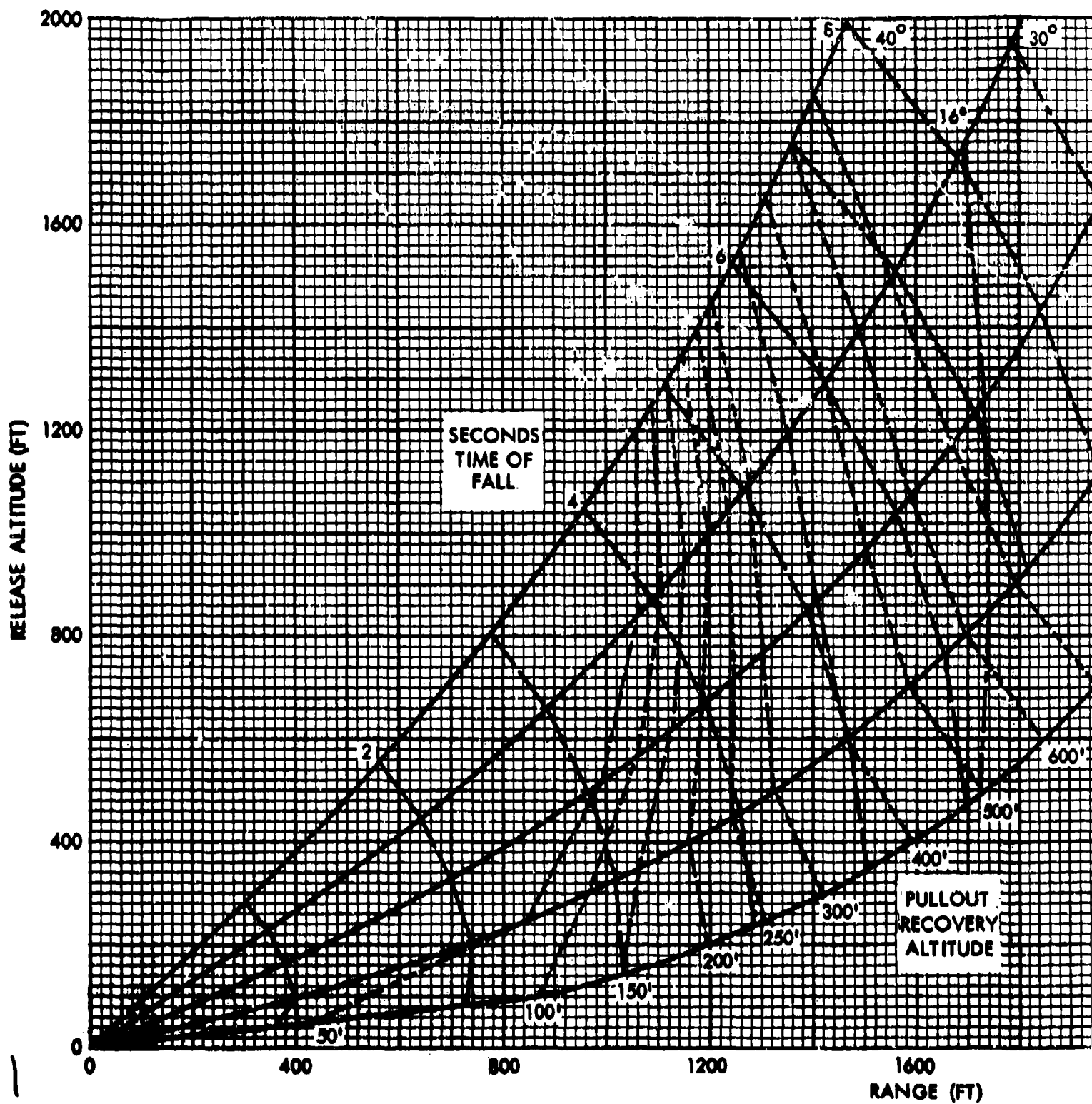




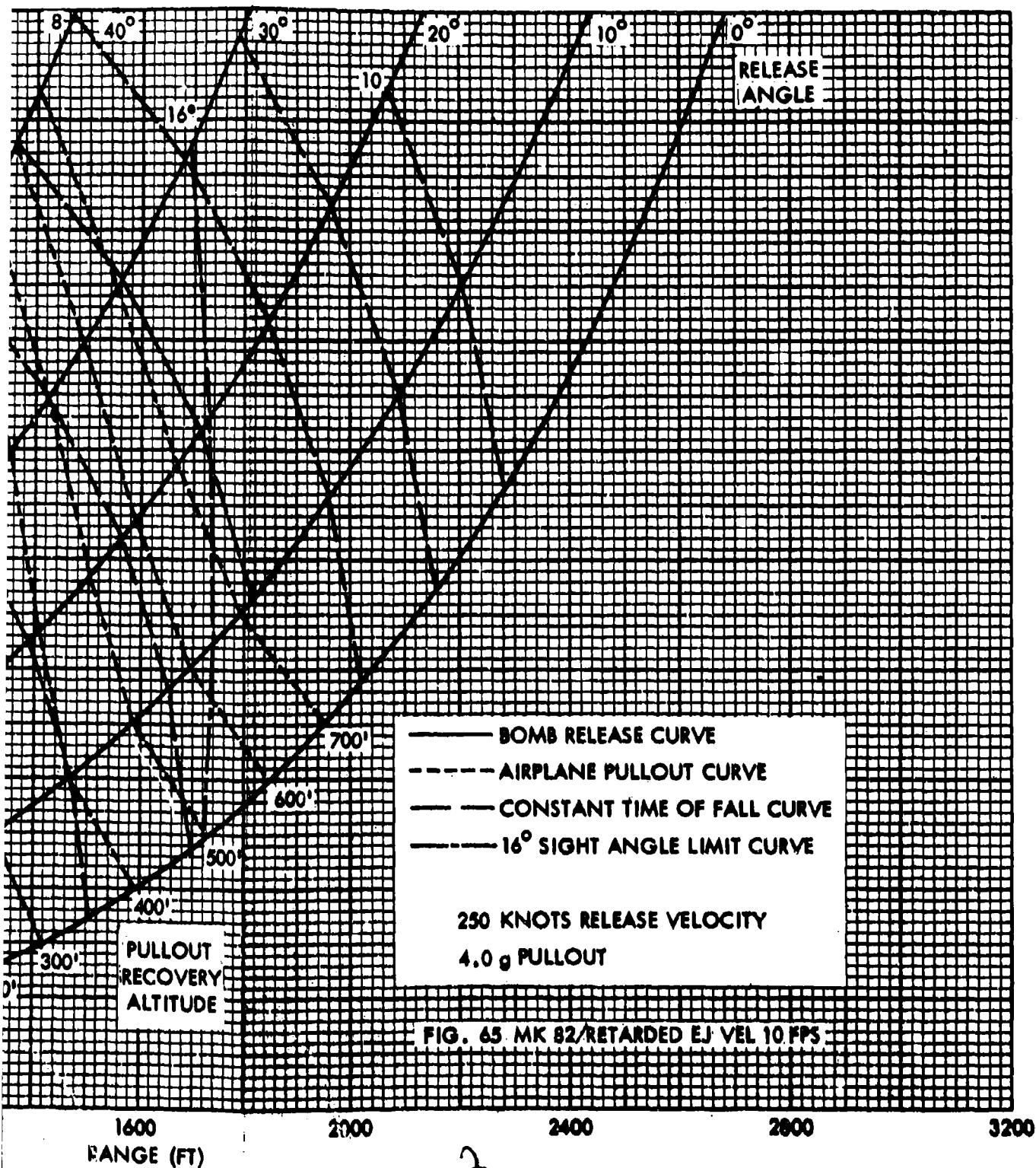
NOLTR 65-230

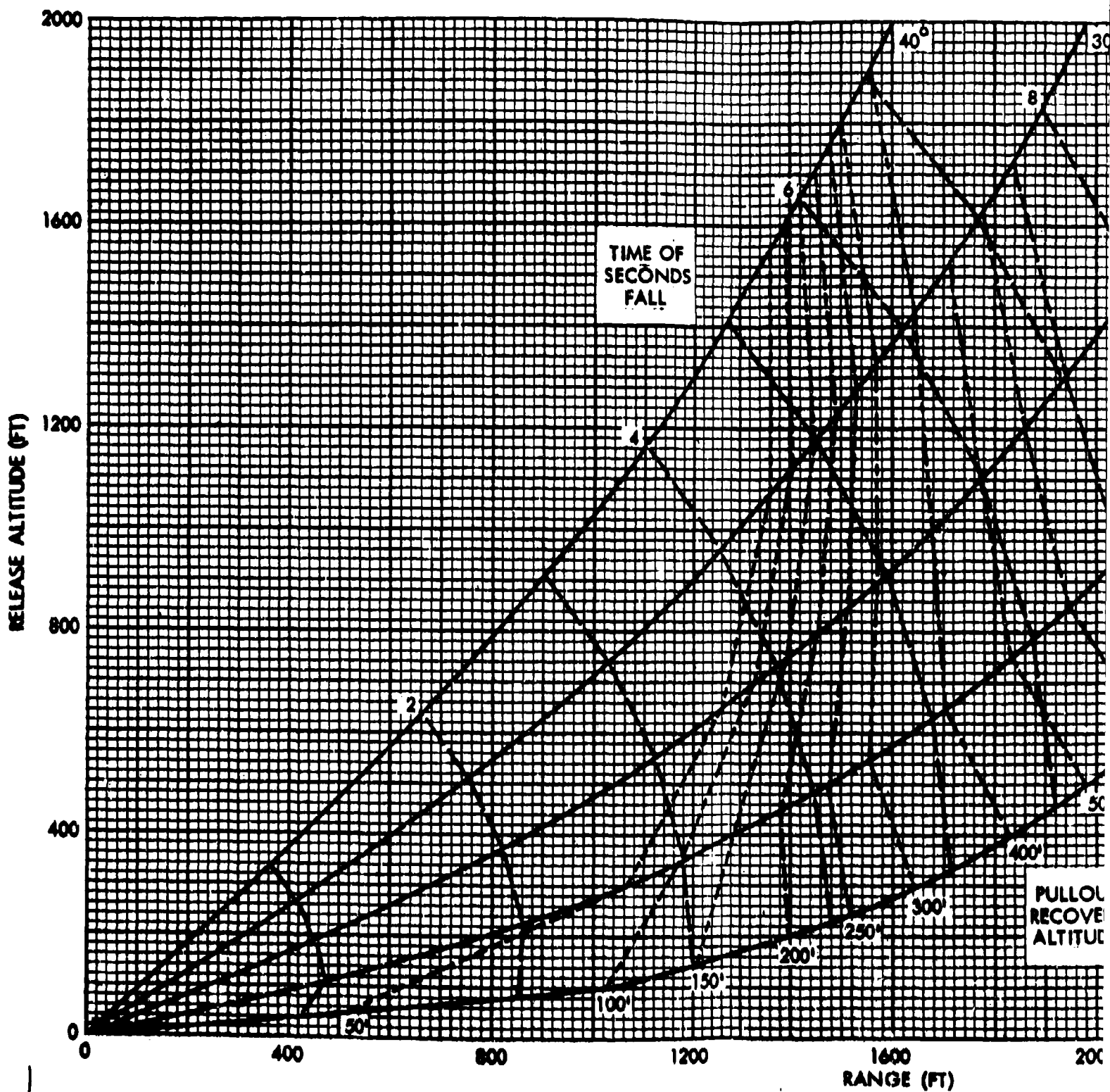


2

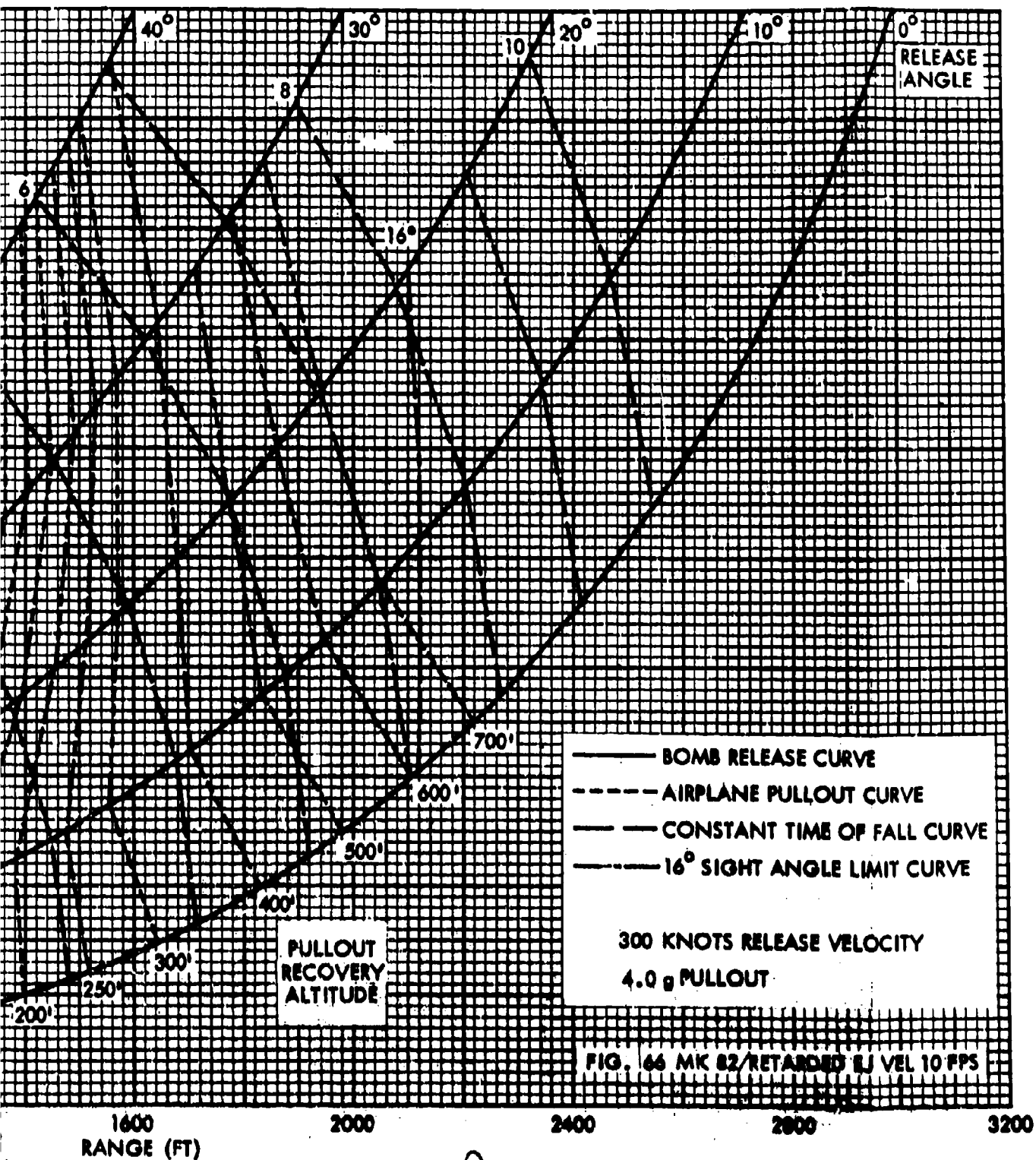


NOLTR 65-230

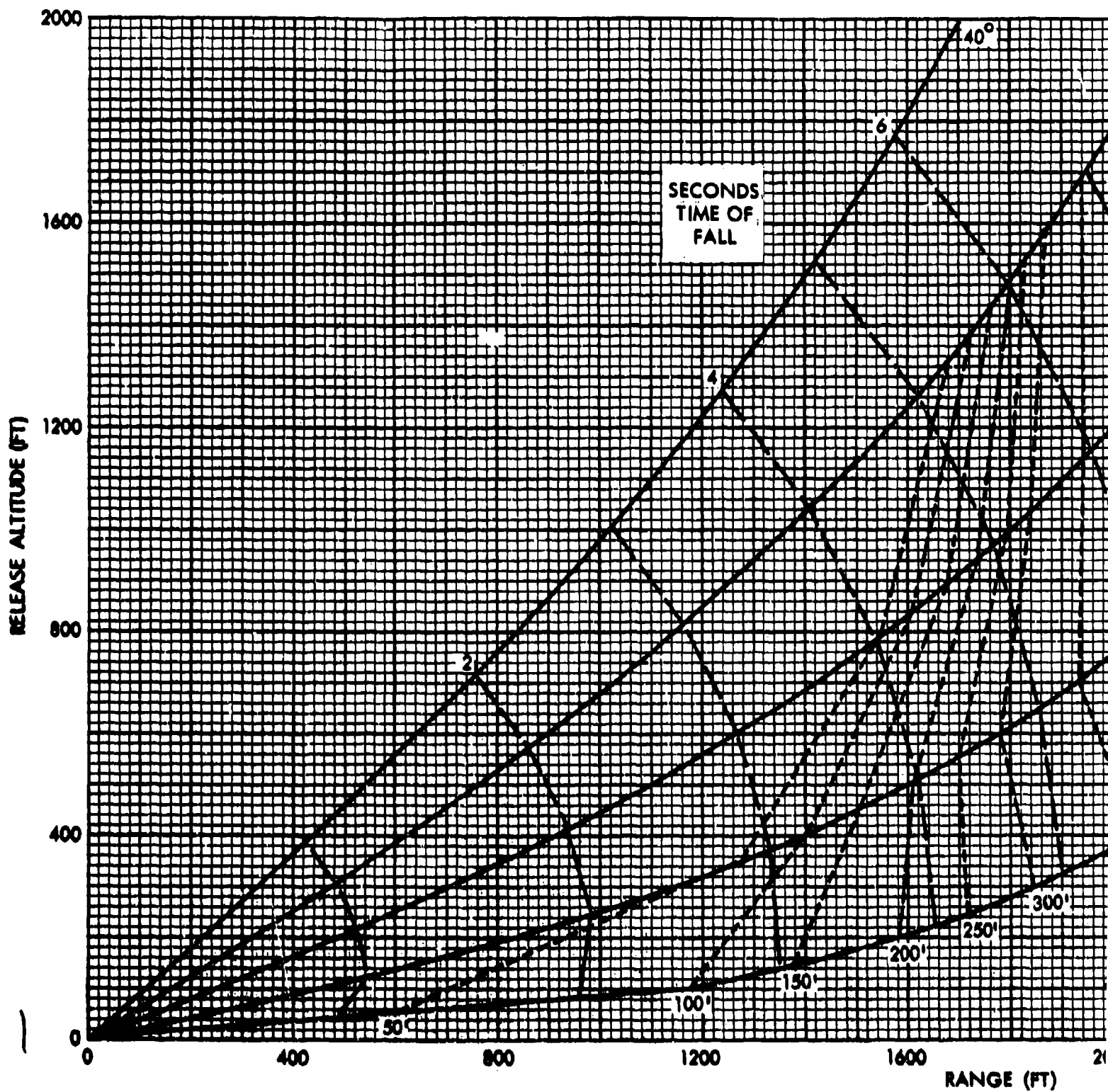


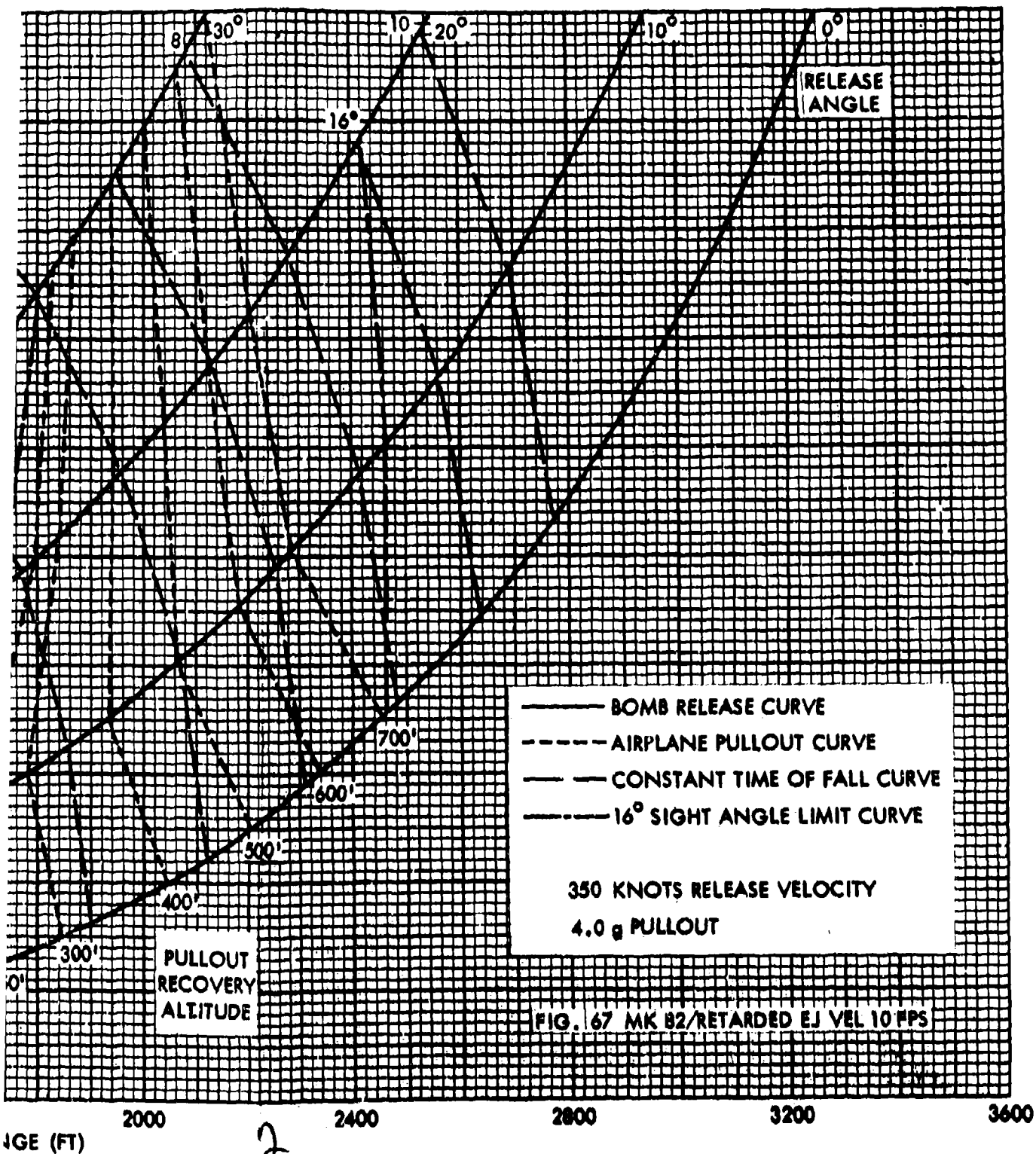


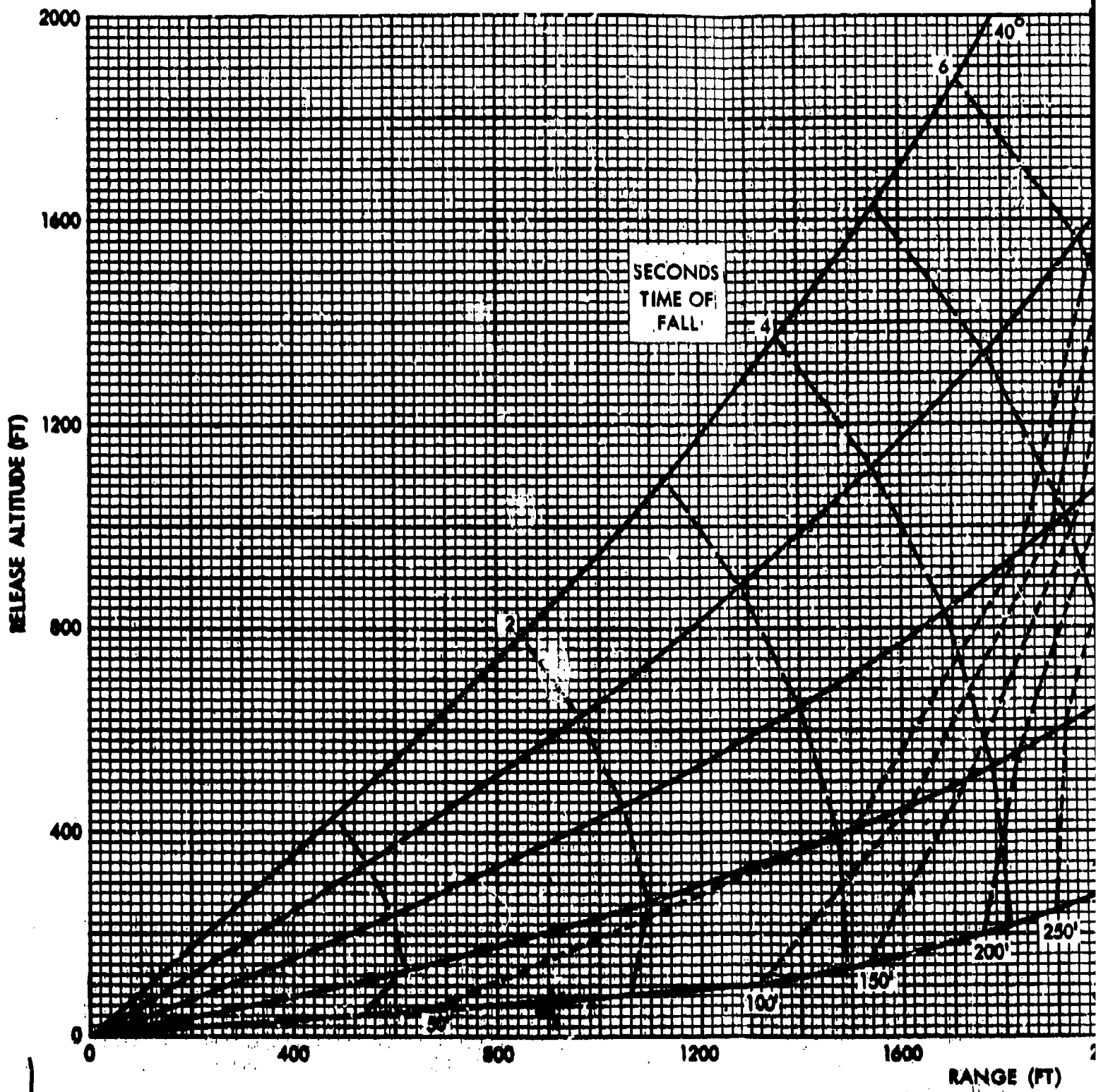
NOLTR 65-230

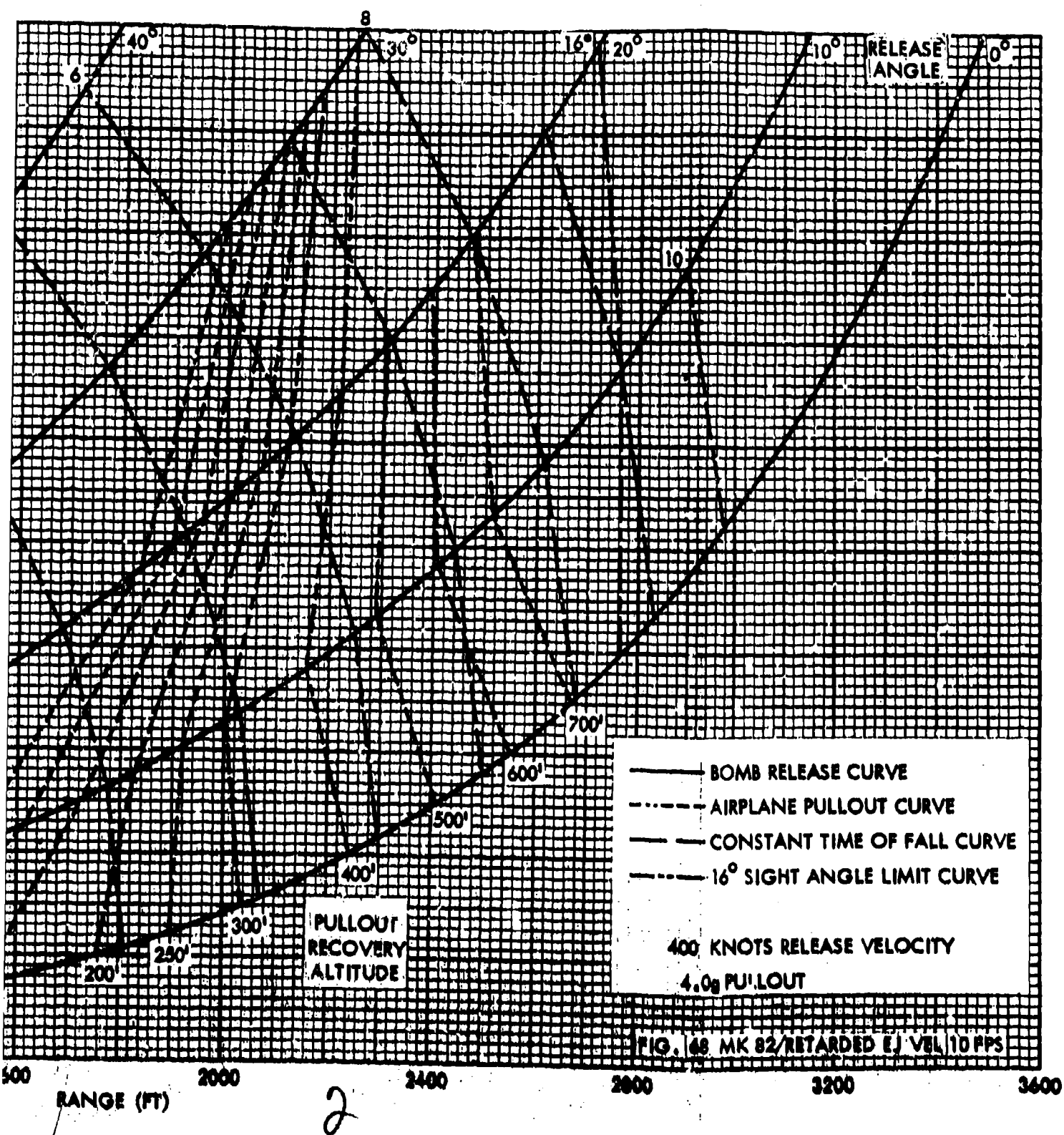


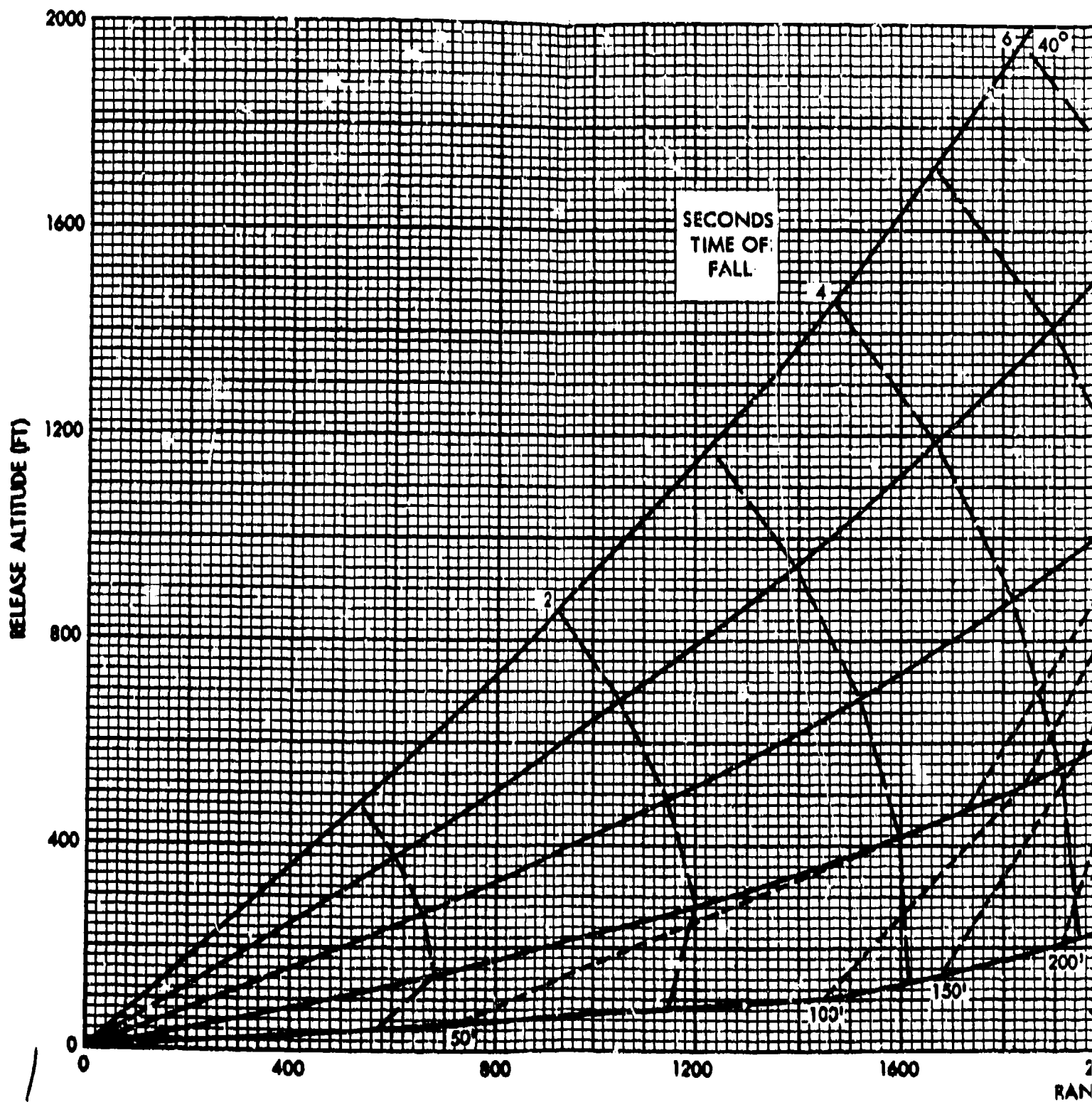
2



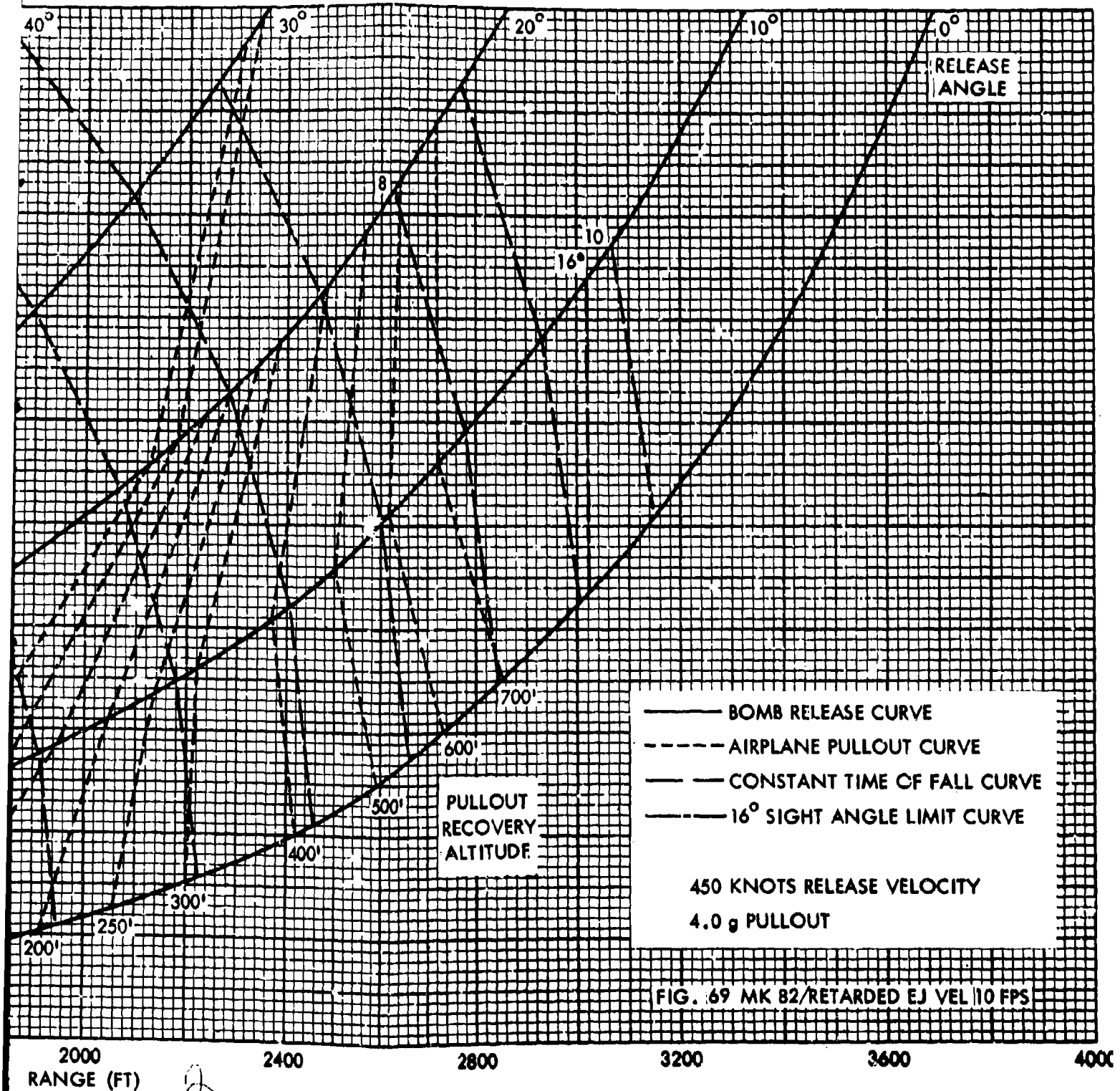


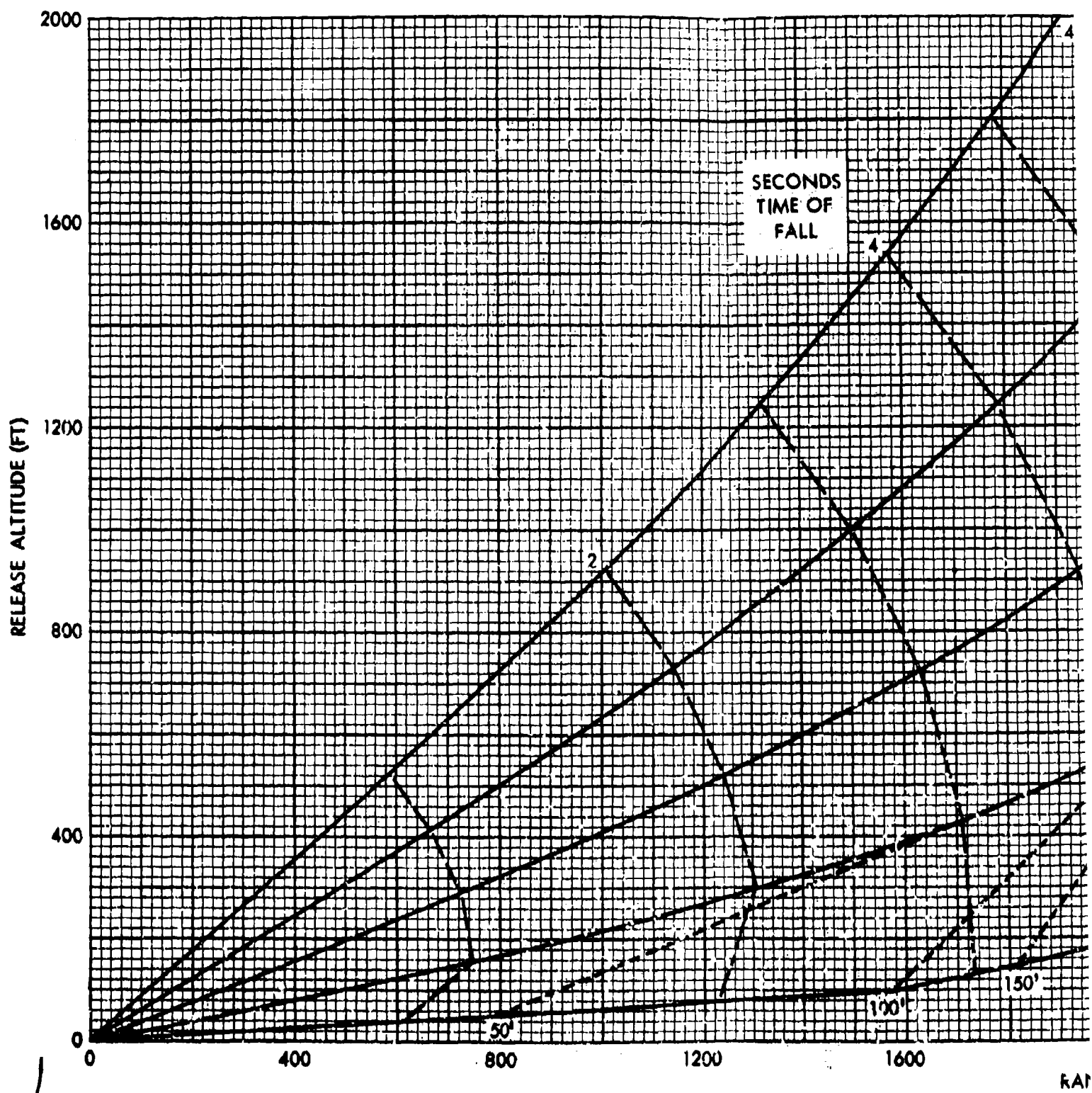






NOLTR 65-230





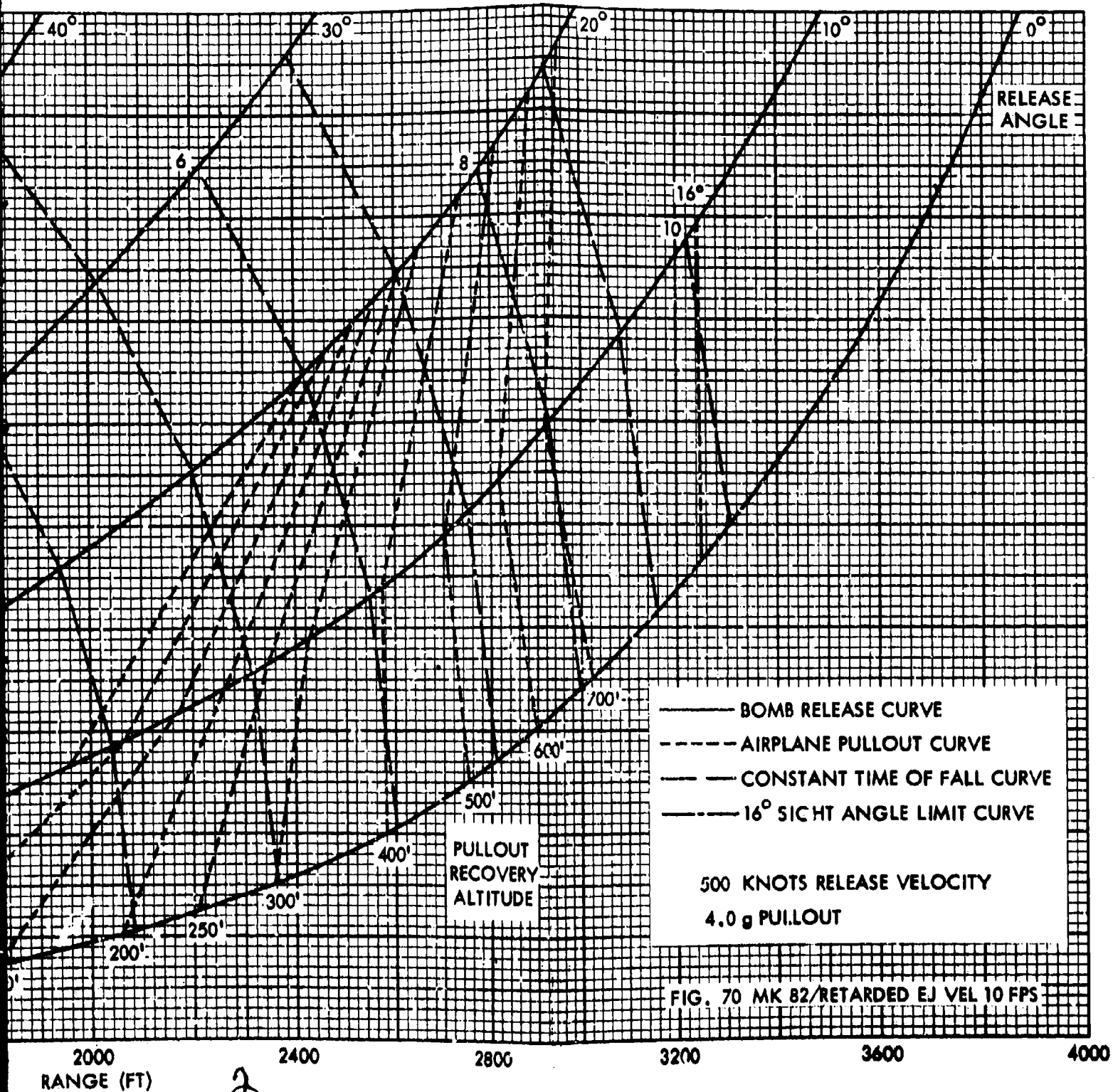
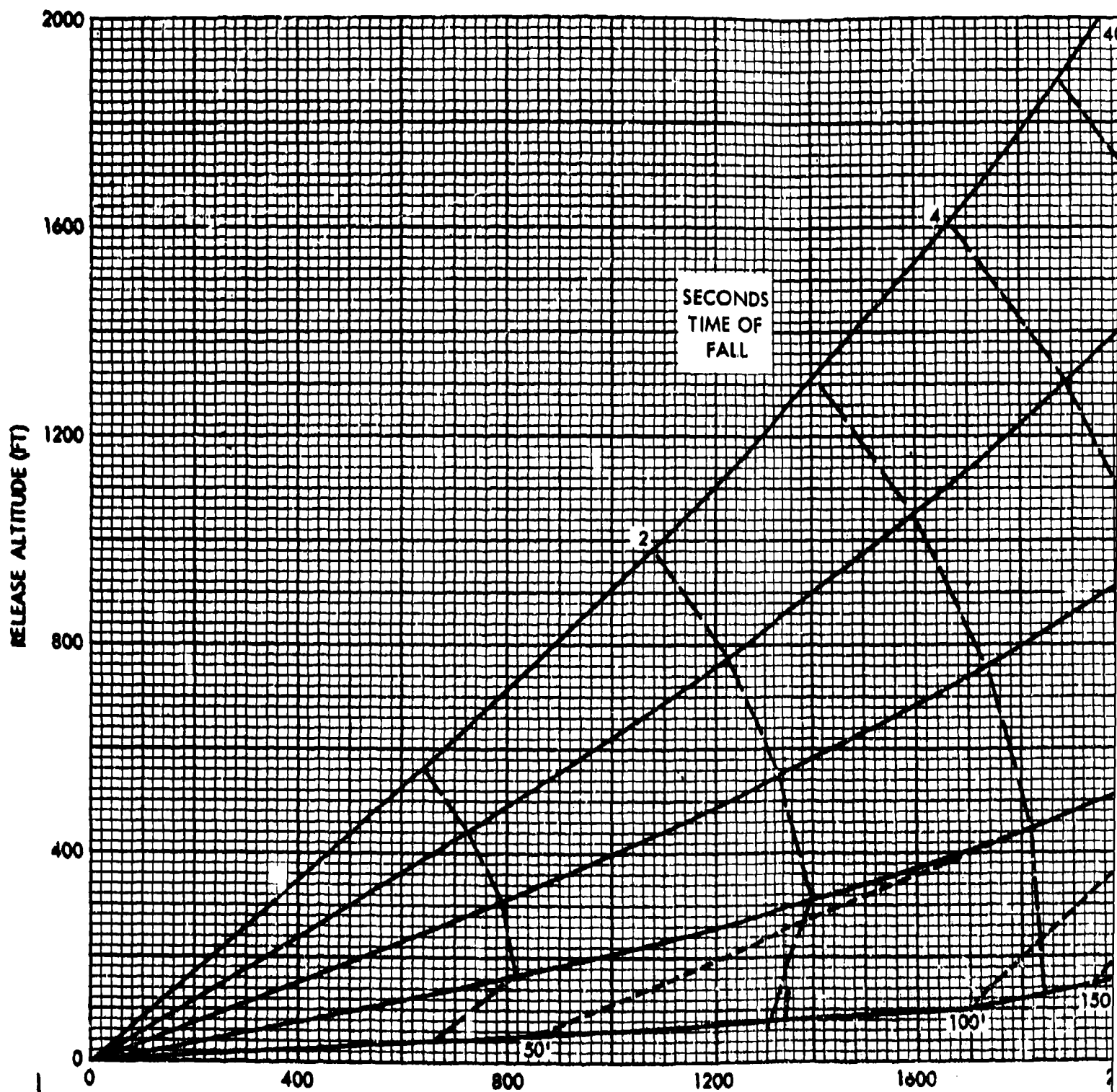
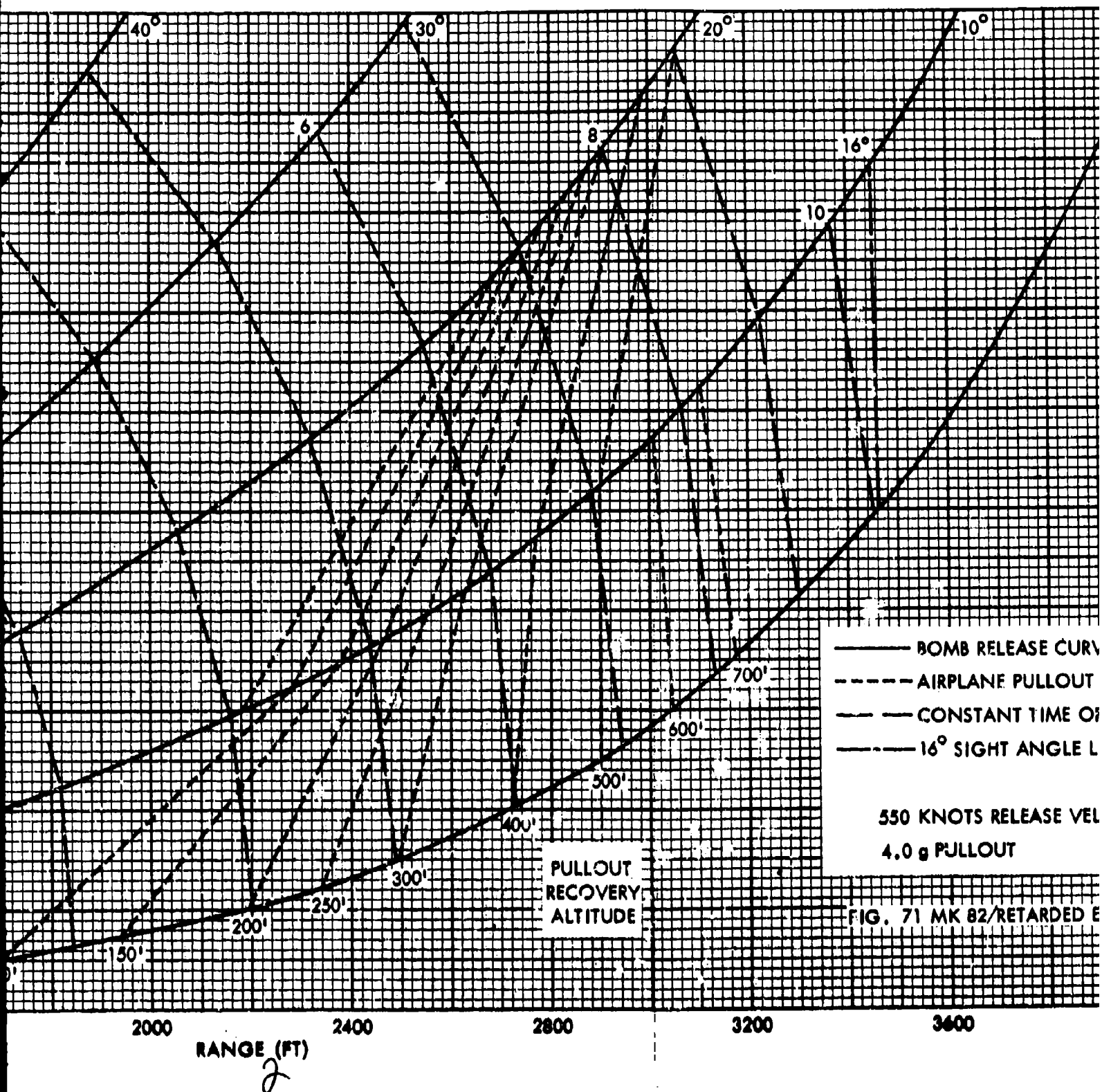
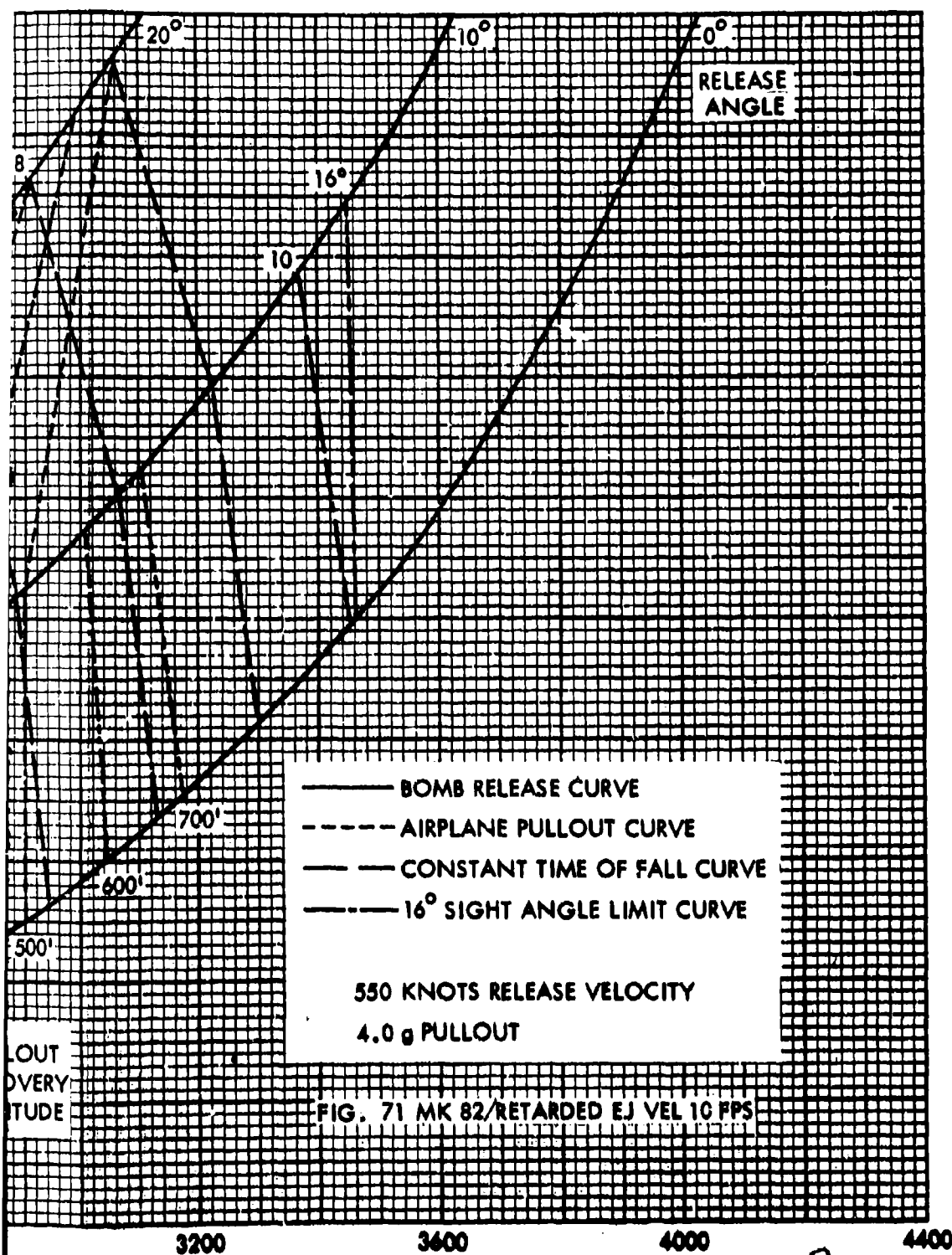
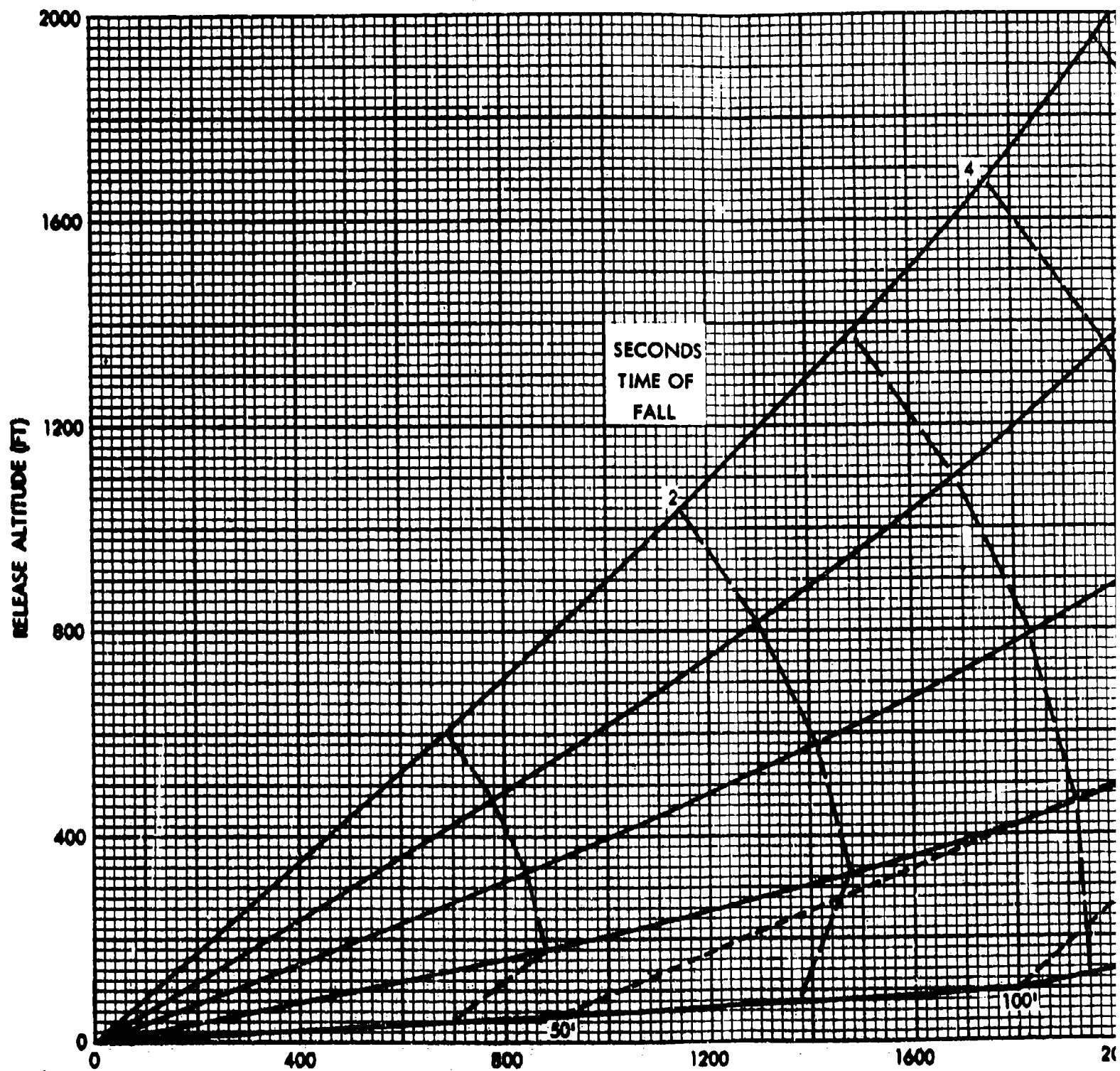


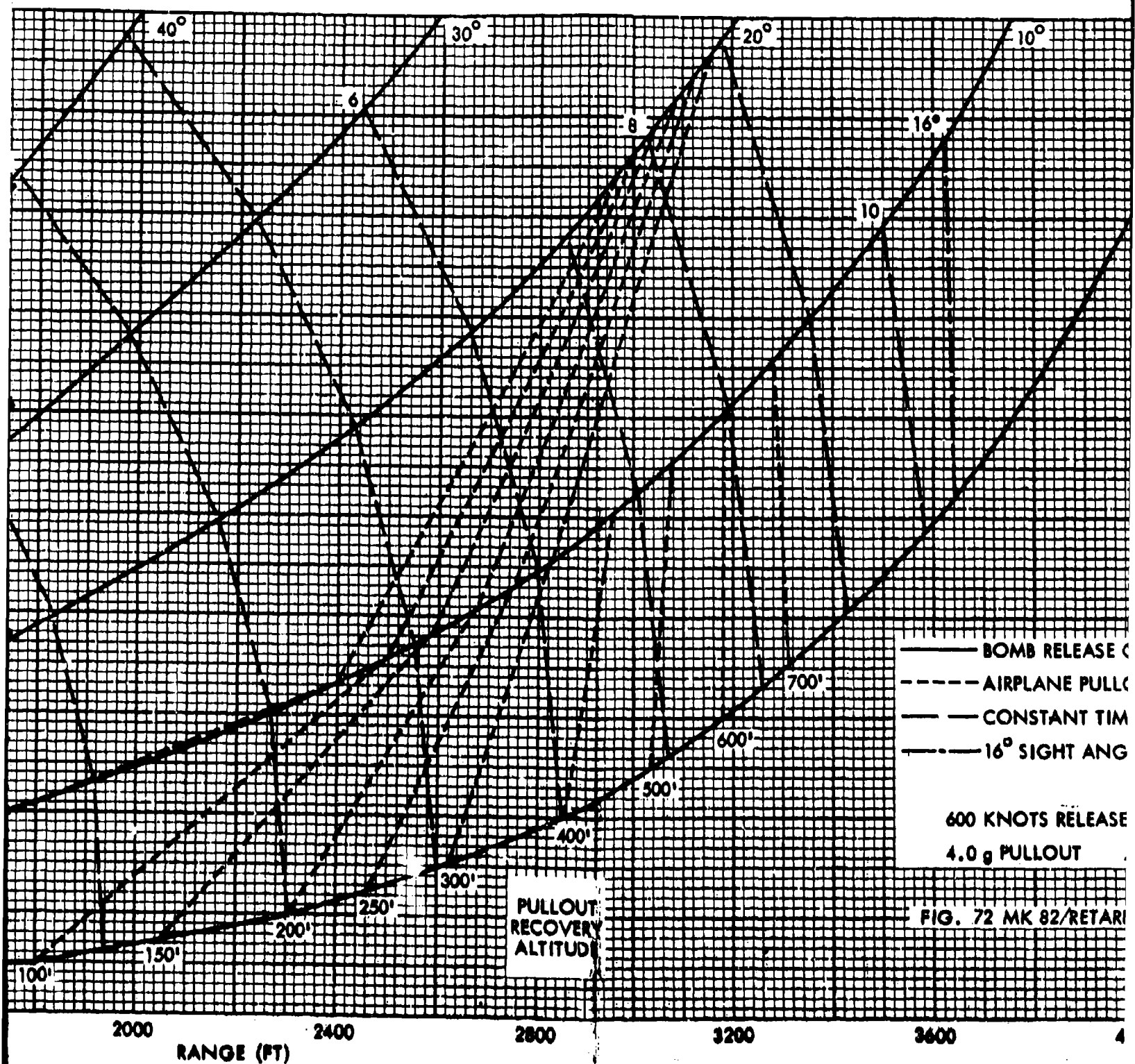
FIG. 70 MK 82/RETARDED EJ VEL 10 FPS

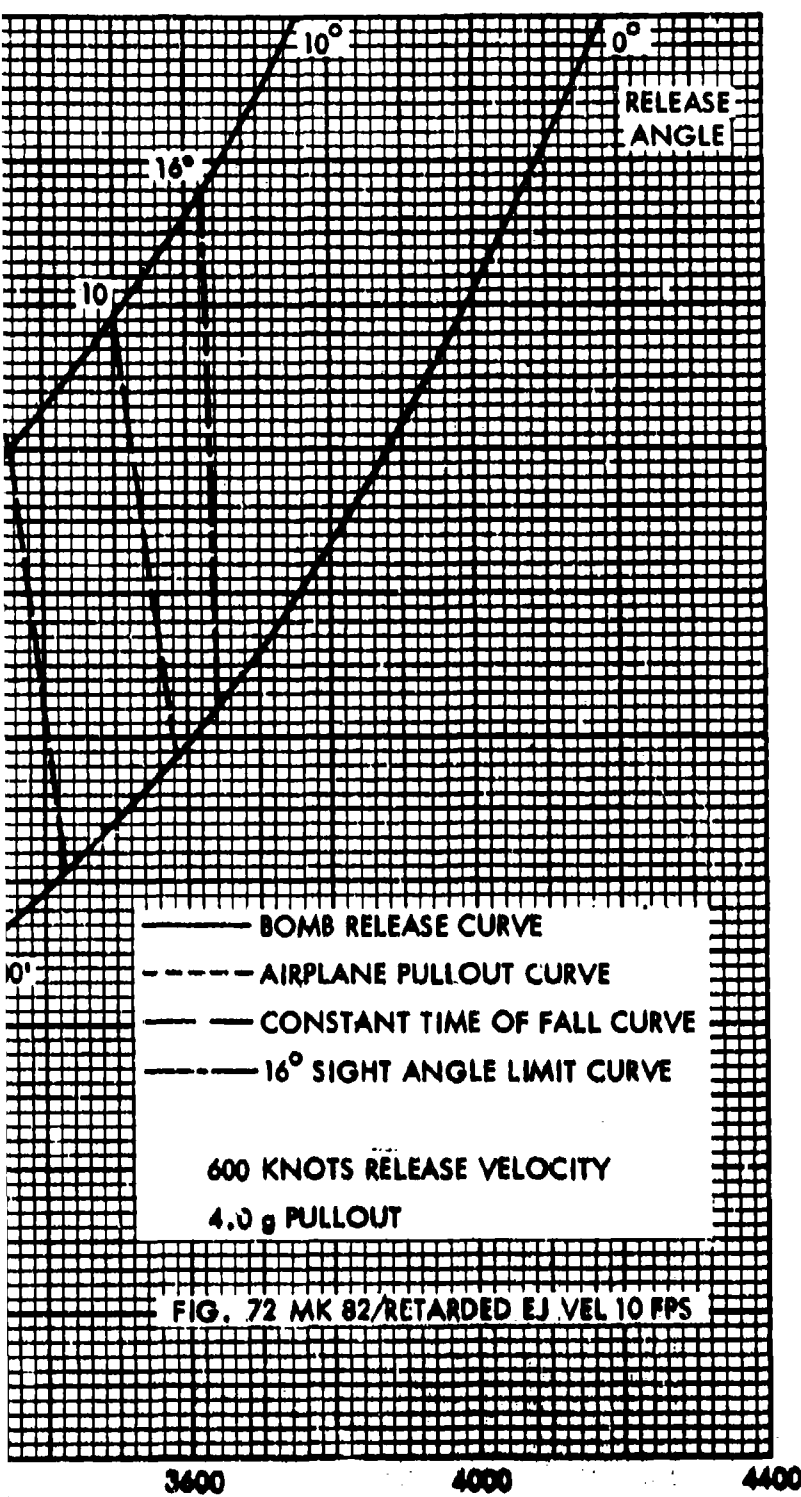


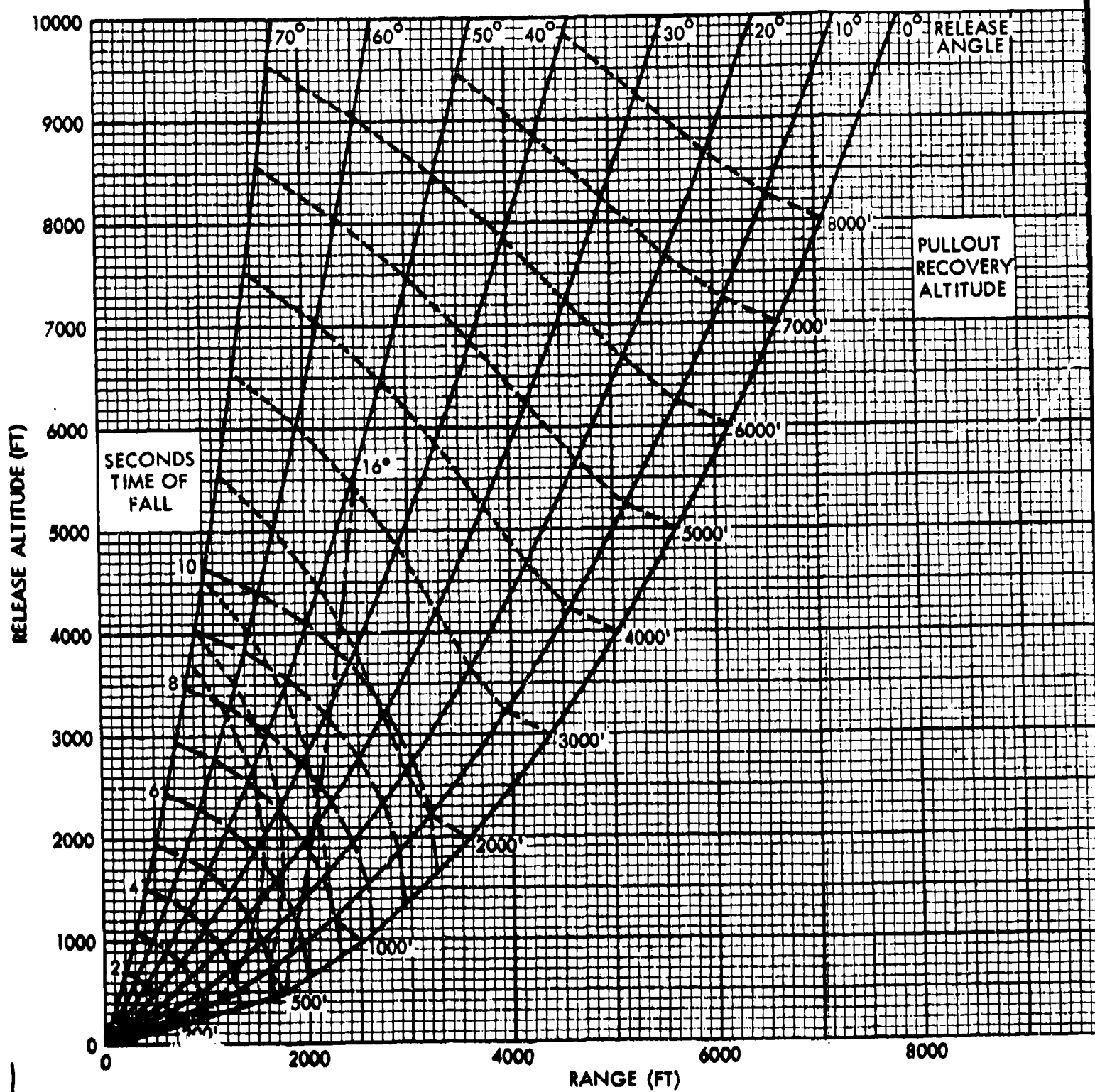




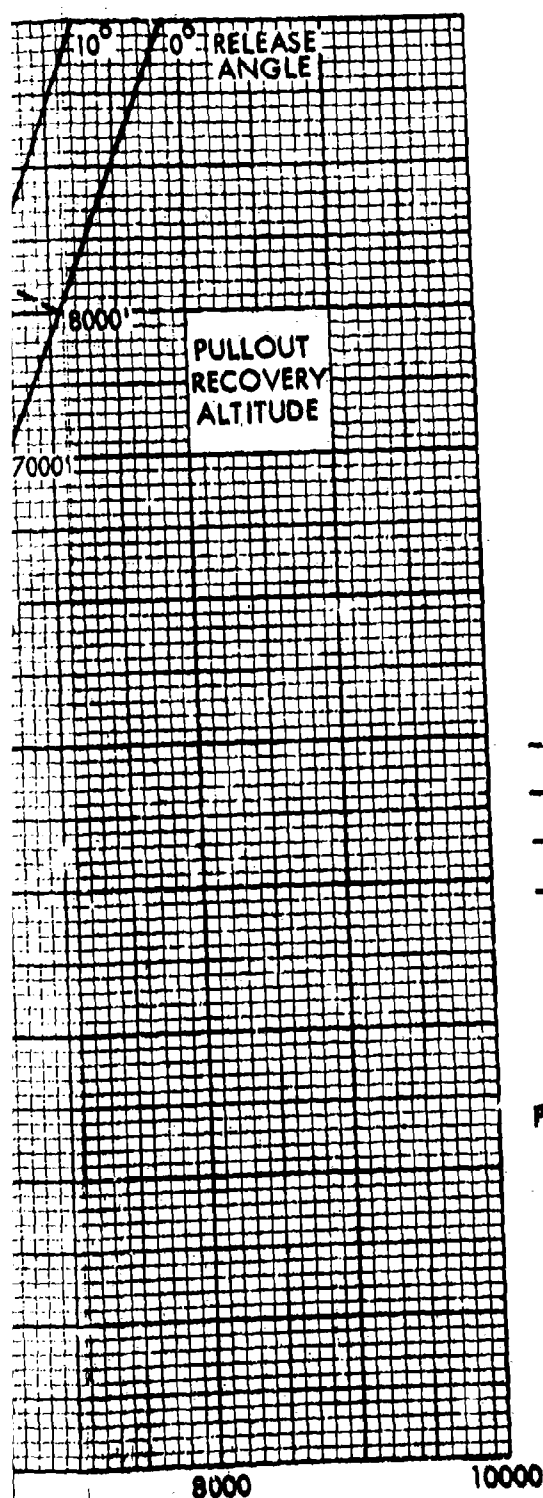








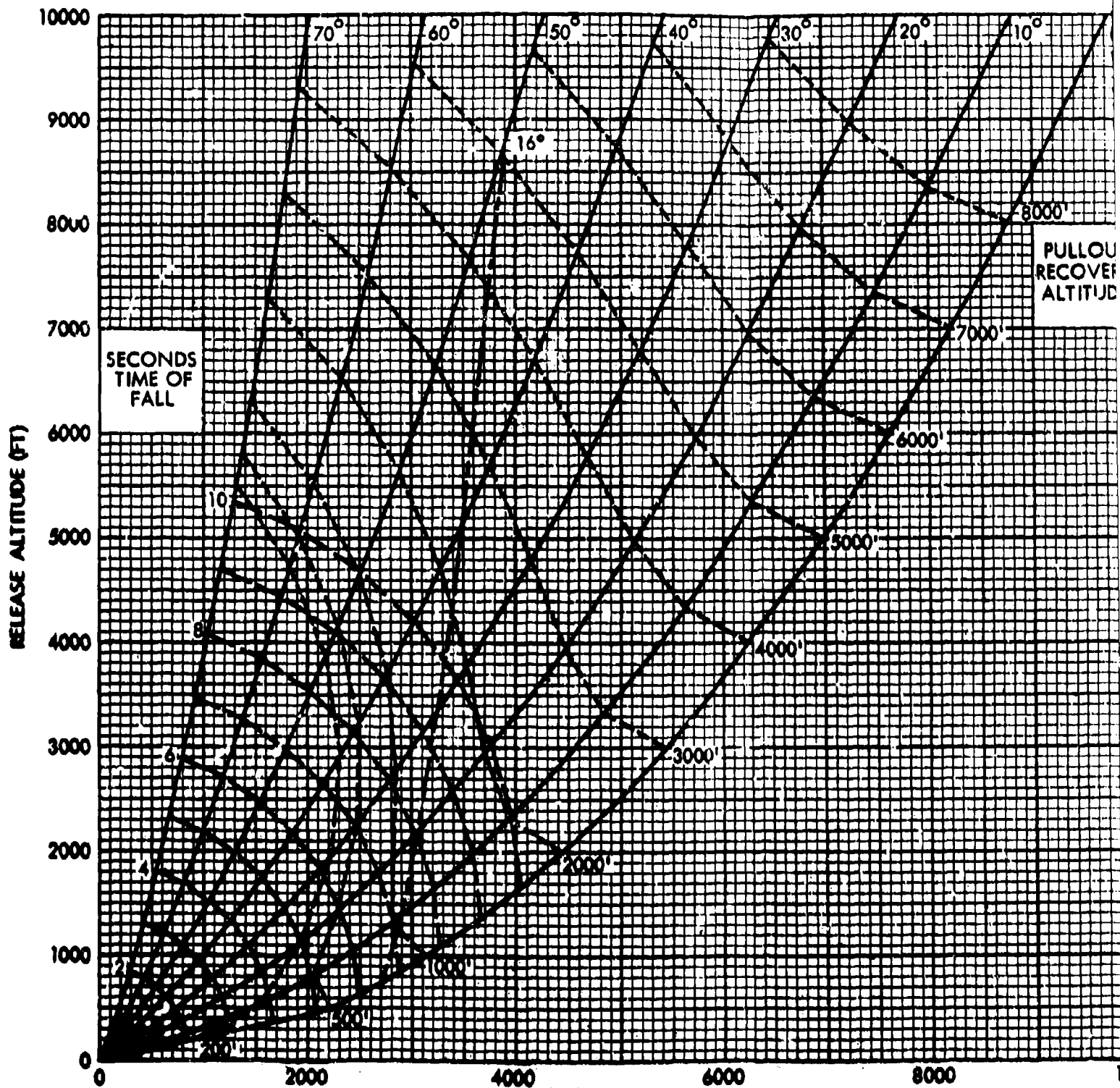
NOLTR 65-230



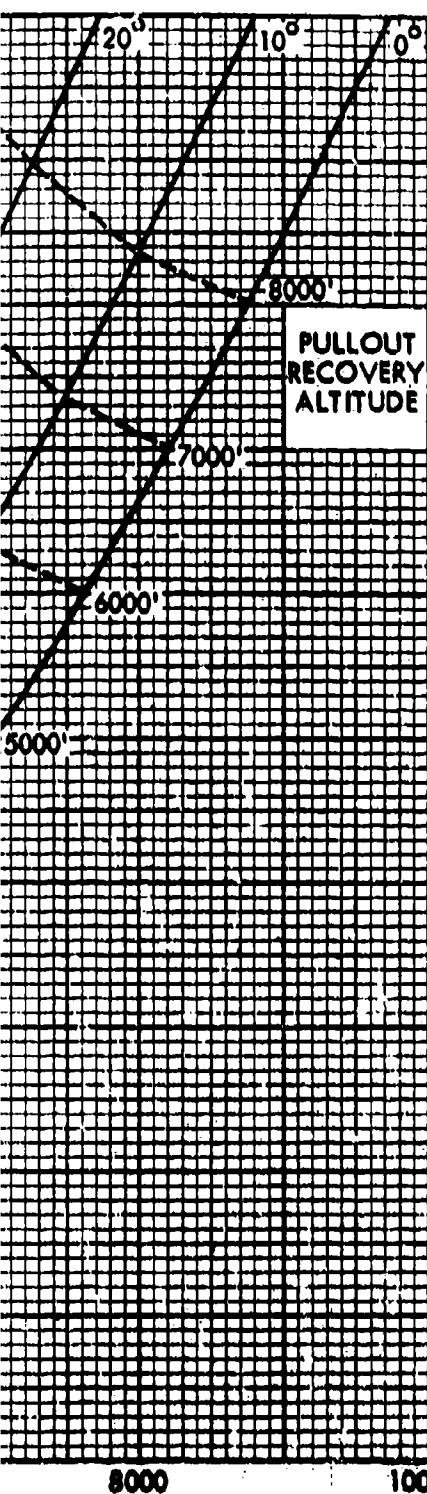
- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY
2.0 g PULLOUT

FIG. 73 MK 81/UNRETARDED EJ VEL 10 FPS



NOLTR 65-230

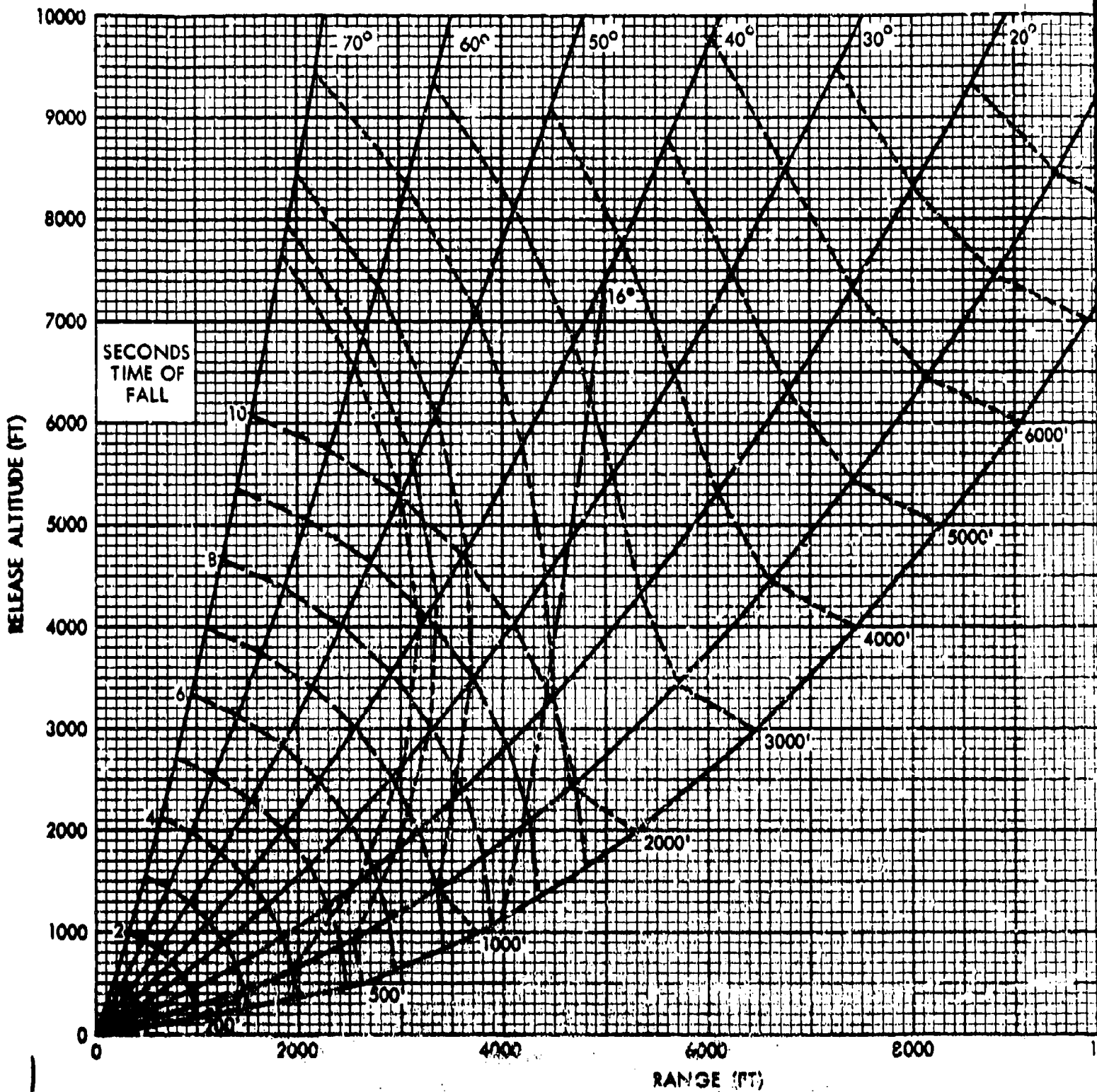


- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

.250 KNOTS RELEASE VELOCITY
2.0 g PULLOUT

FIG.74 MK 81/UNRETARDED EJ VEL 10 FPS

2



NOLTR 65-230

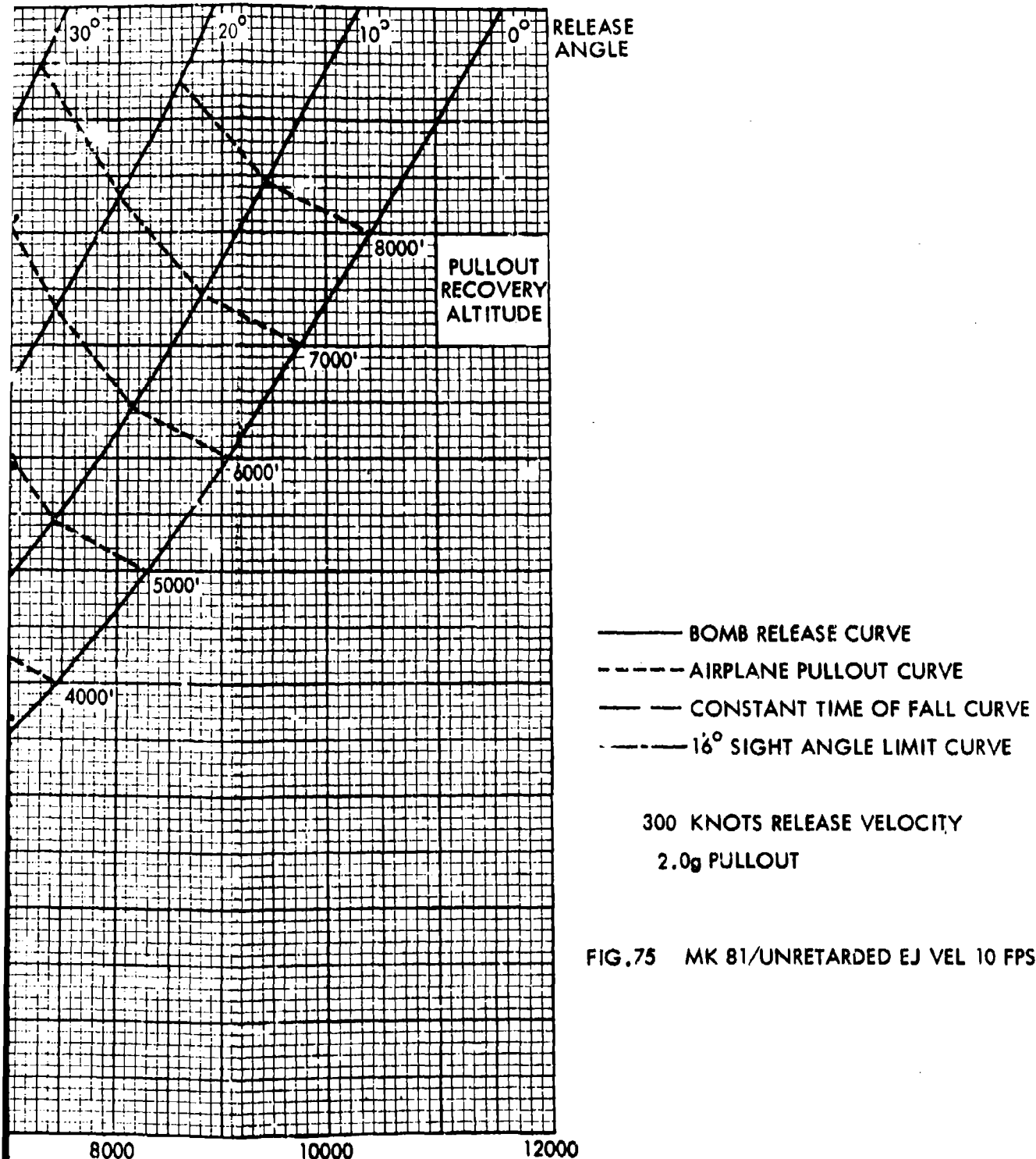
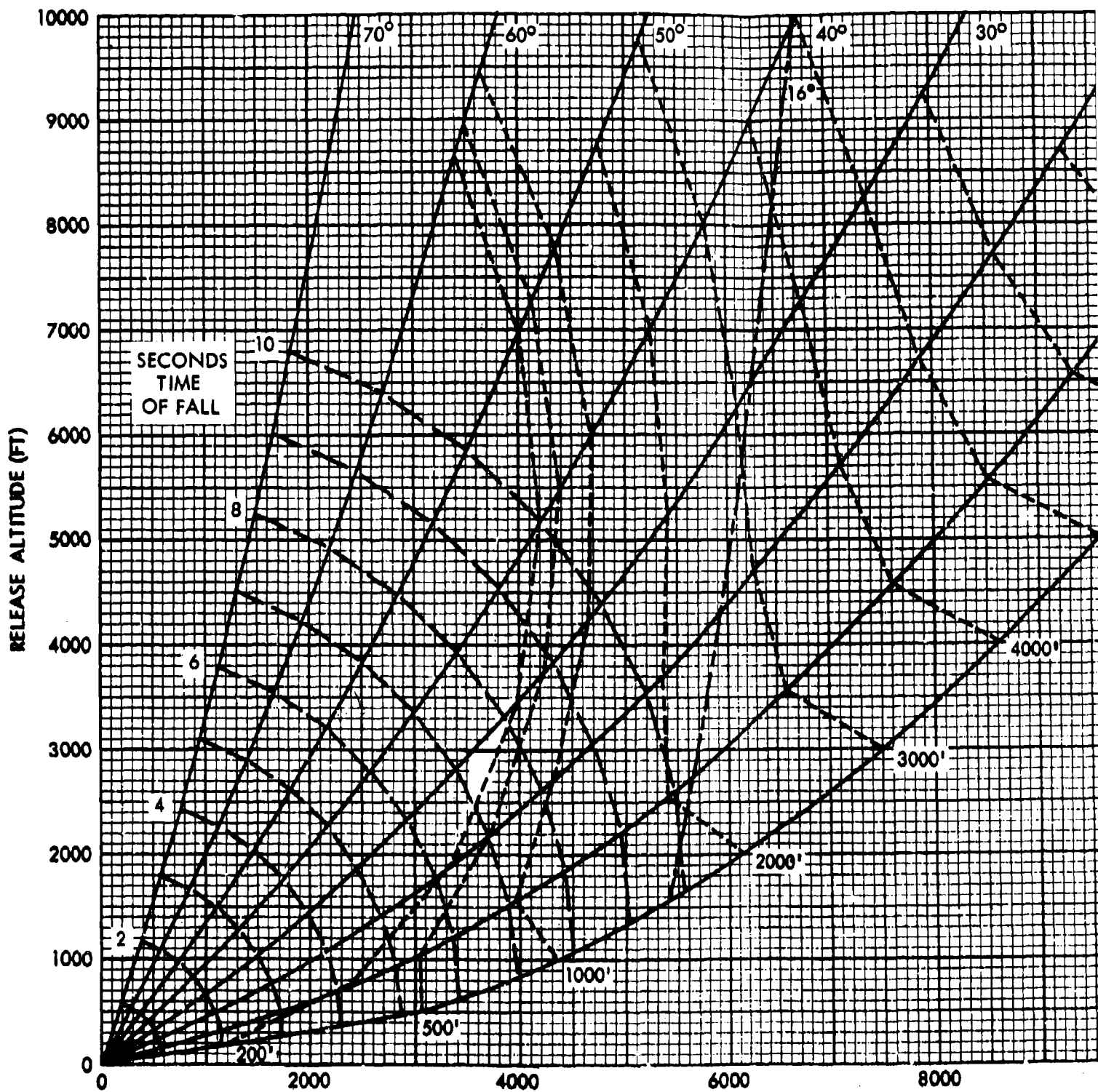
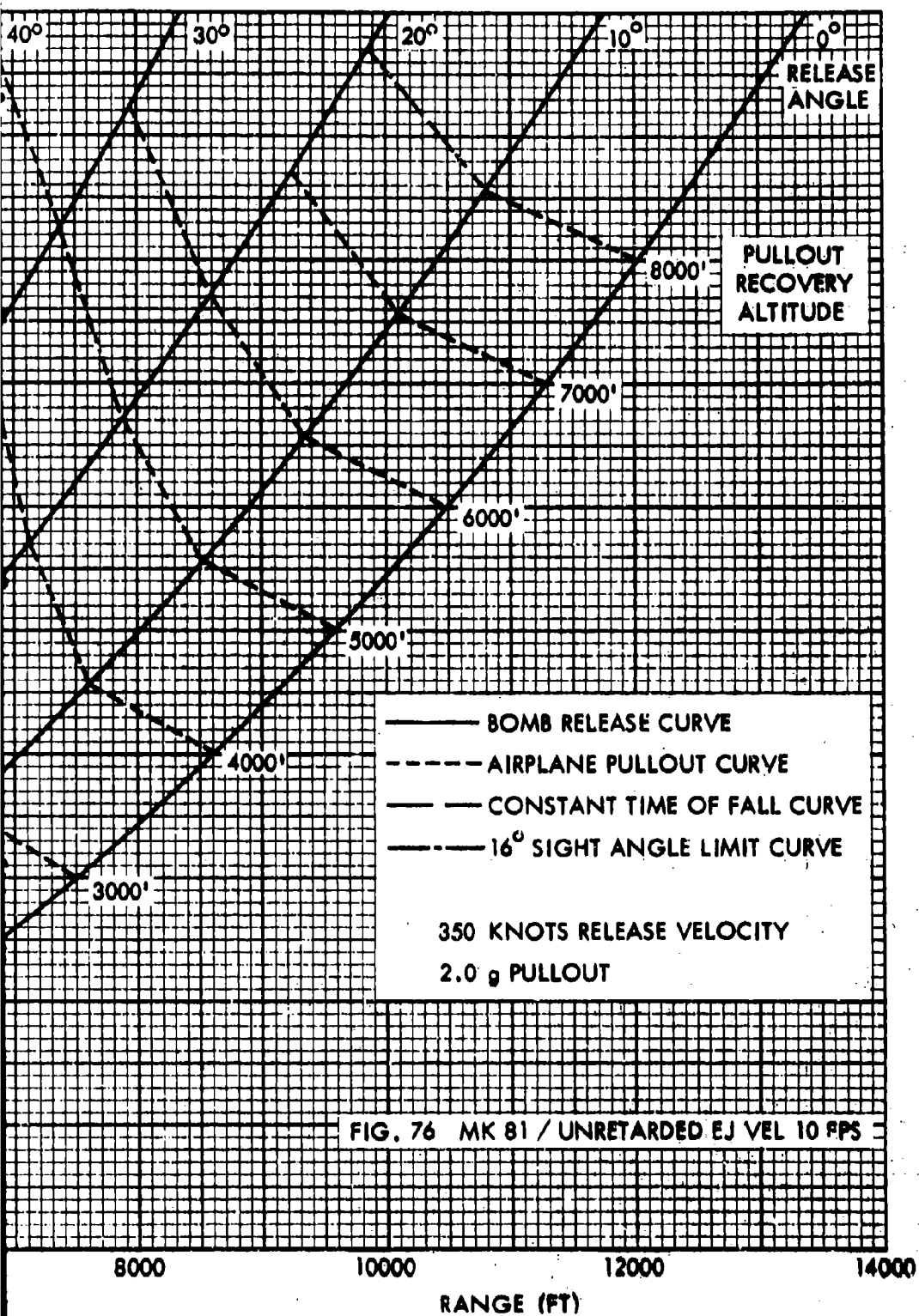
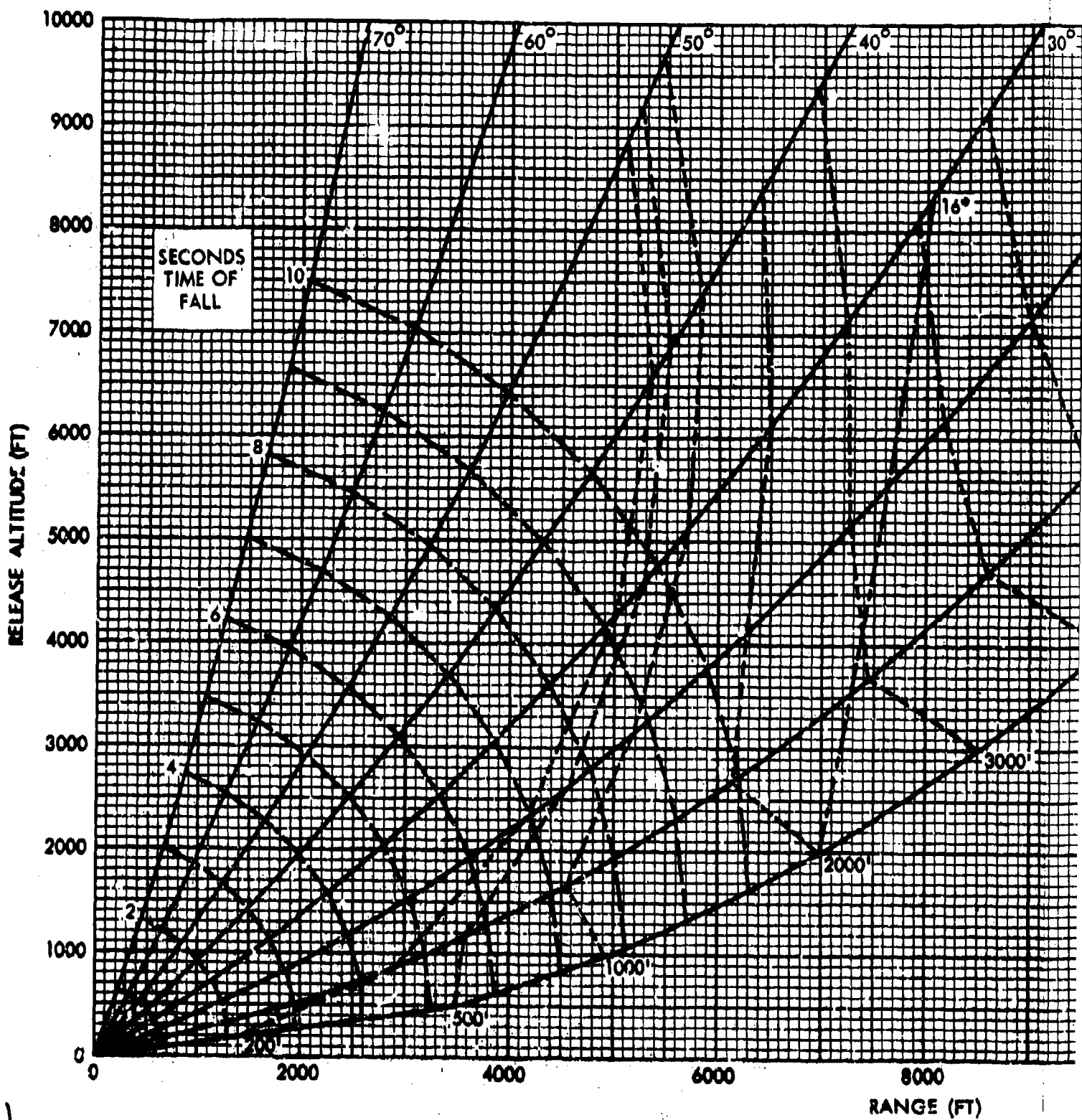


FIG.75 MK 81/UNRETARDED EJ VEL 10 FPS

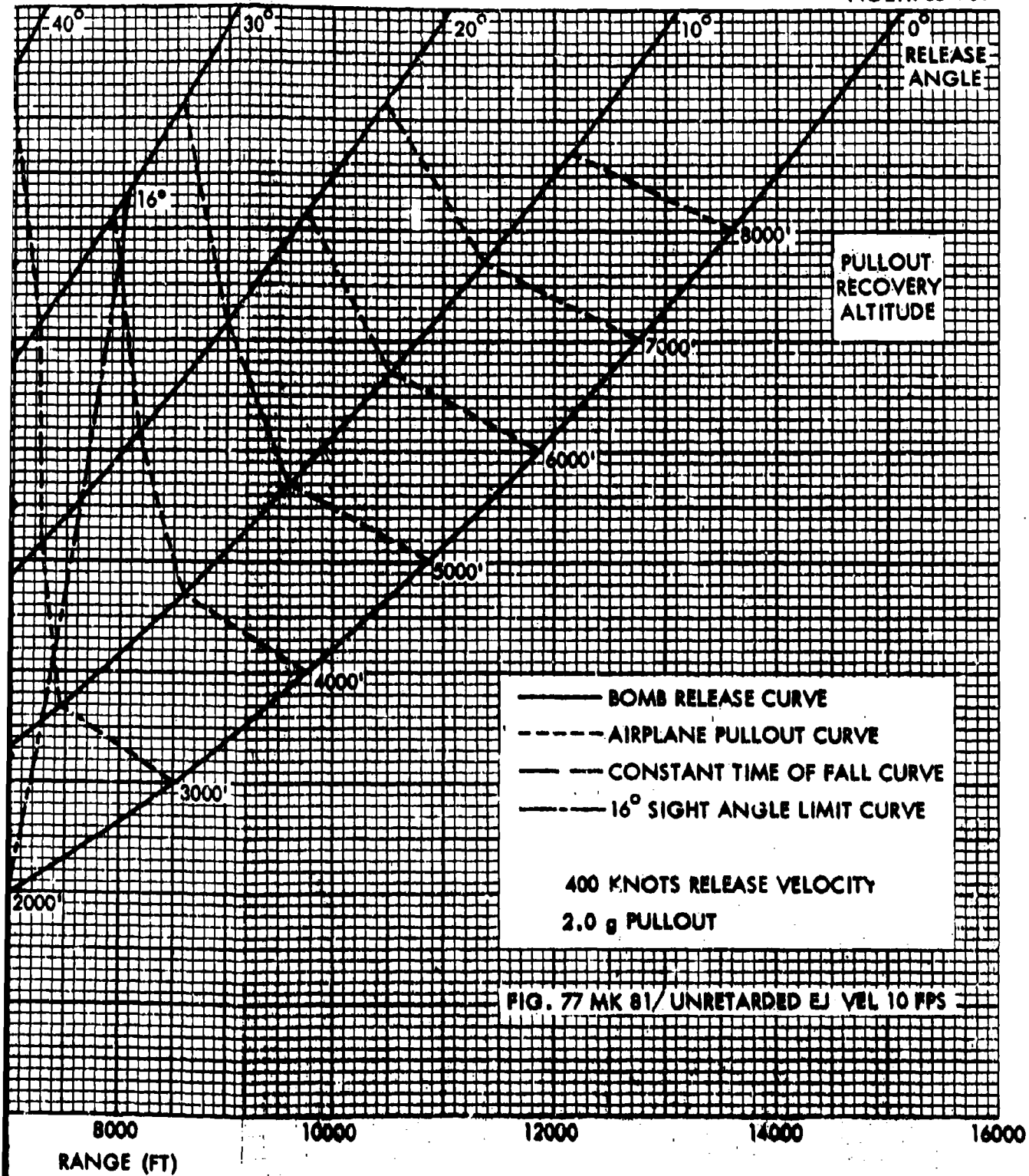


NOLTR 65-230

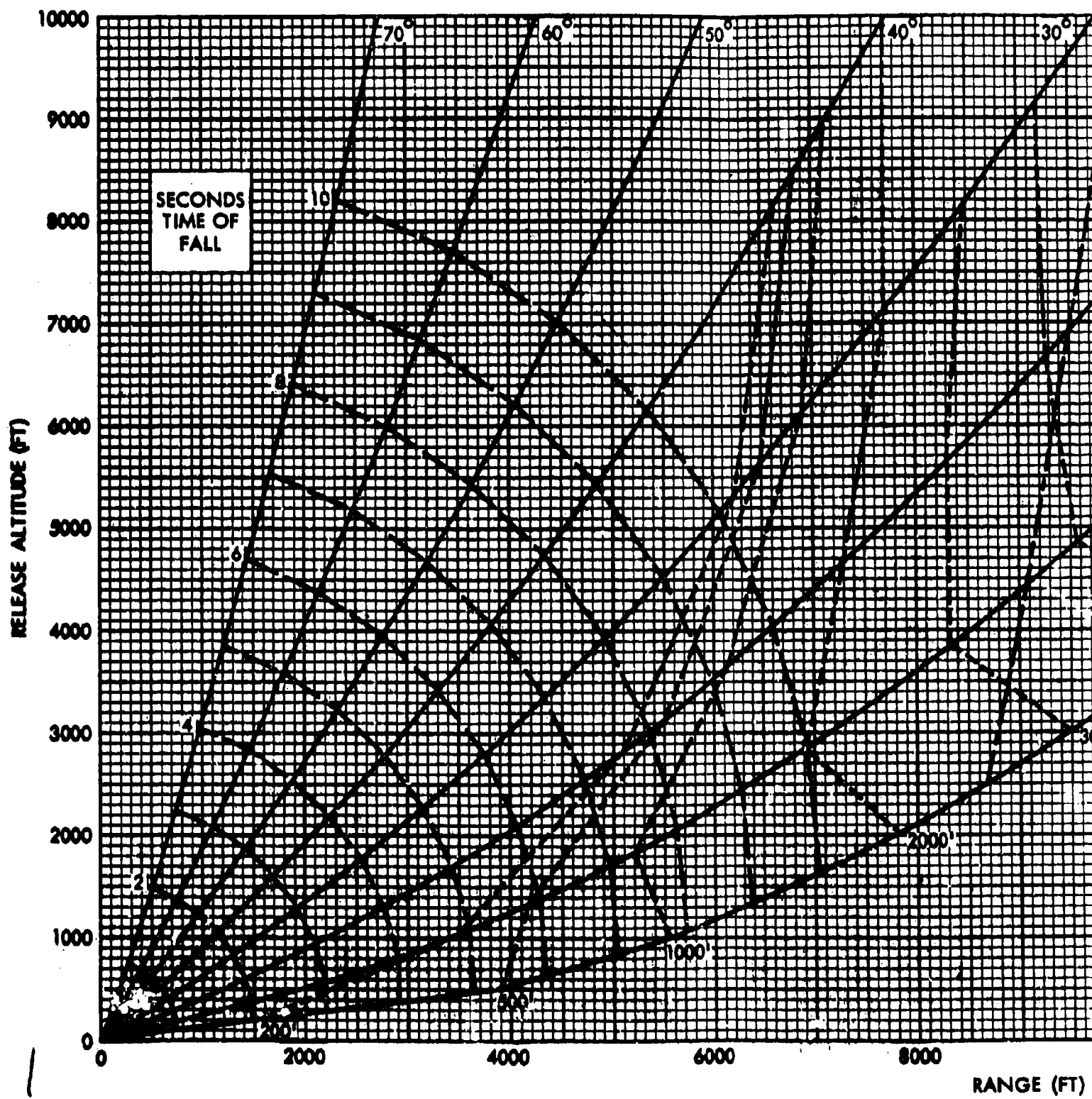




NOLTR 65-230



2



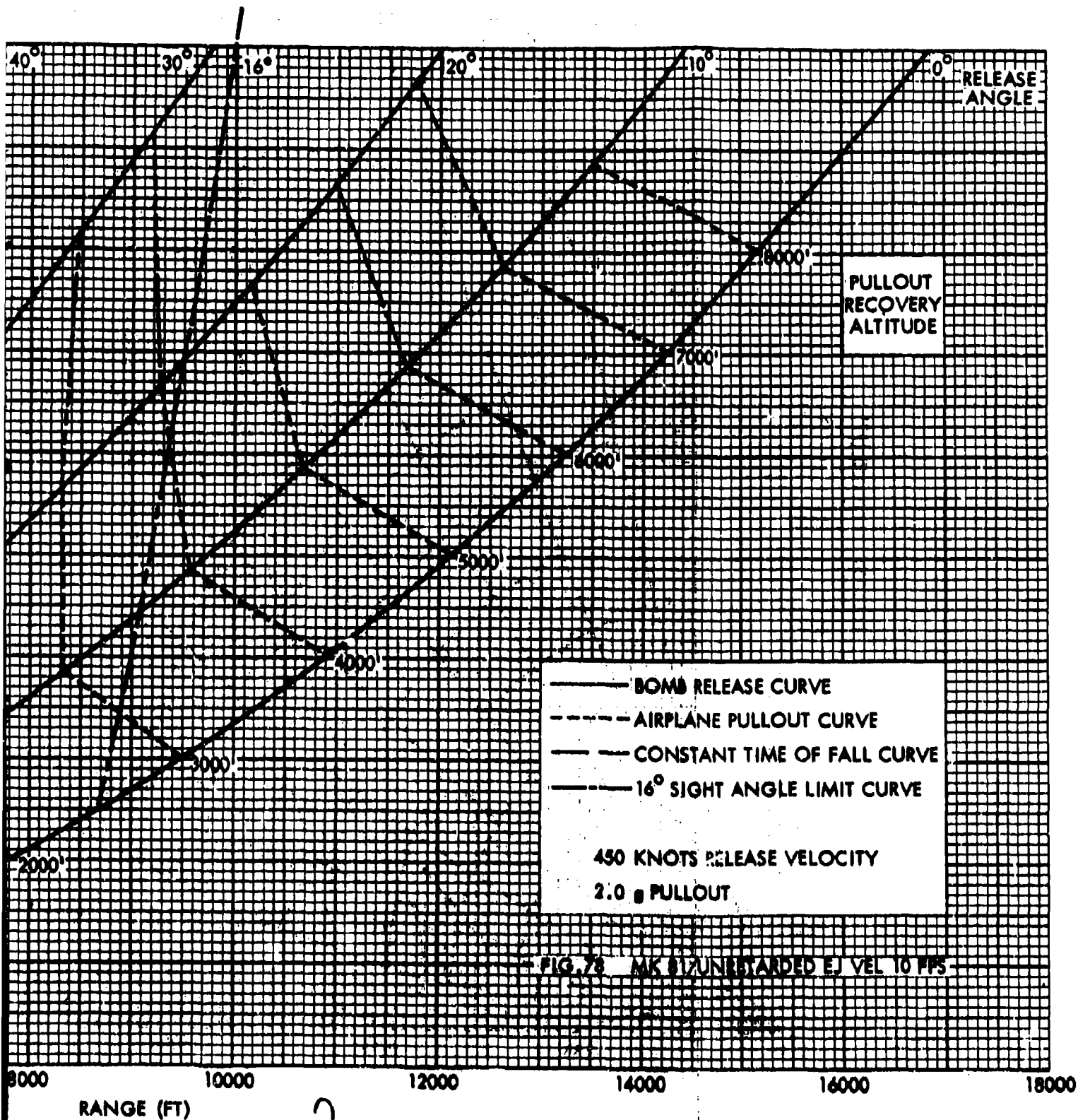
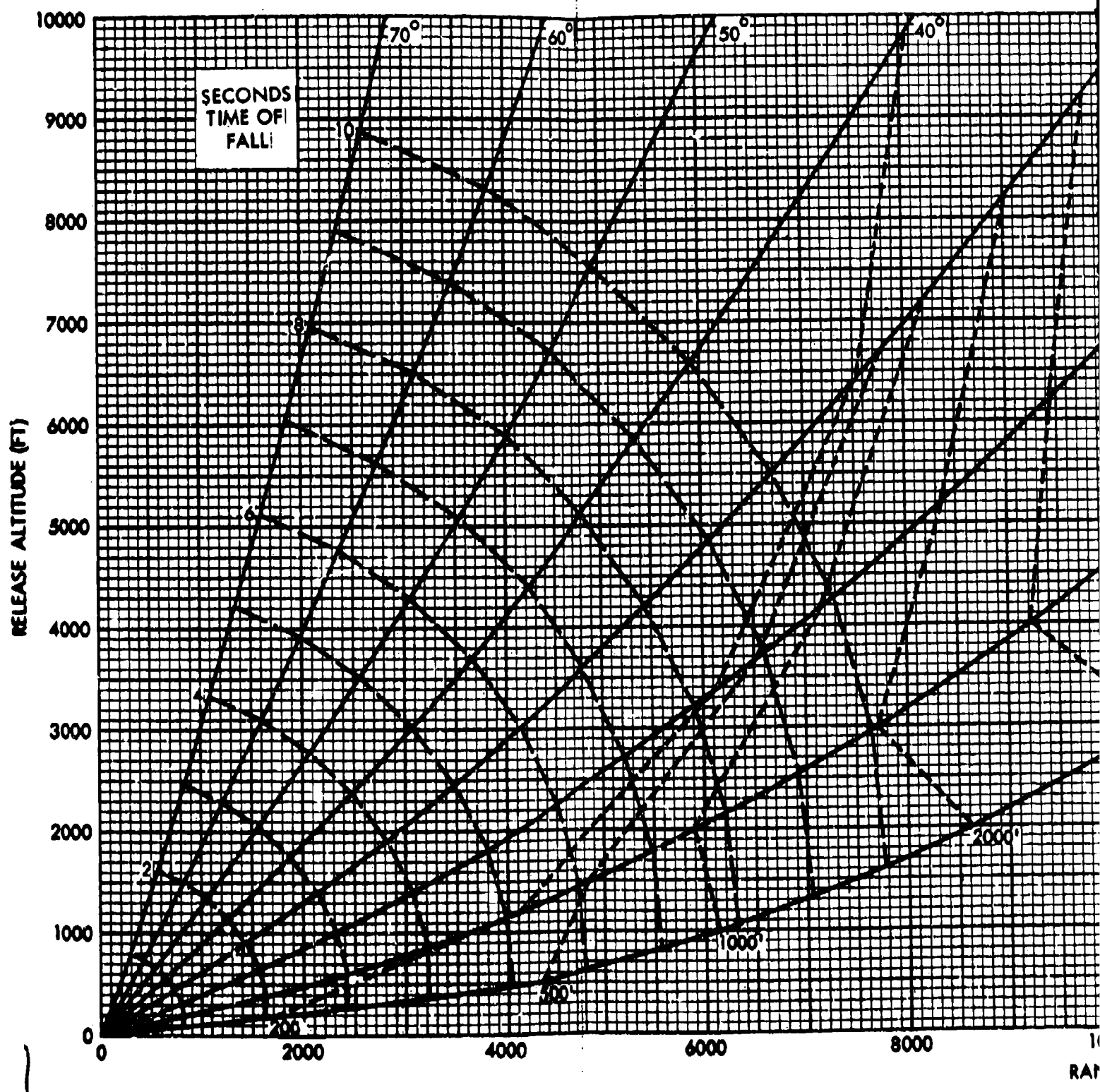
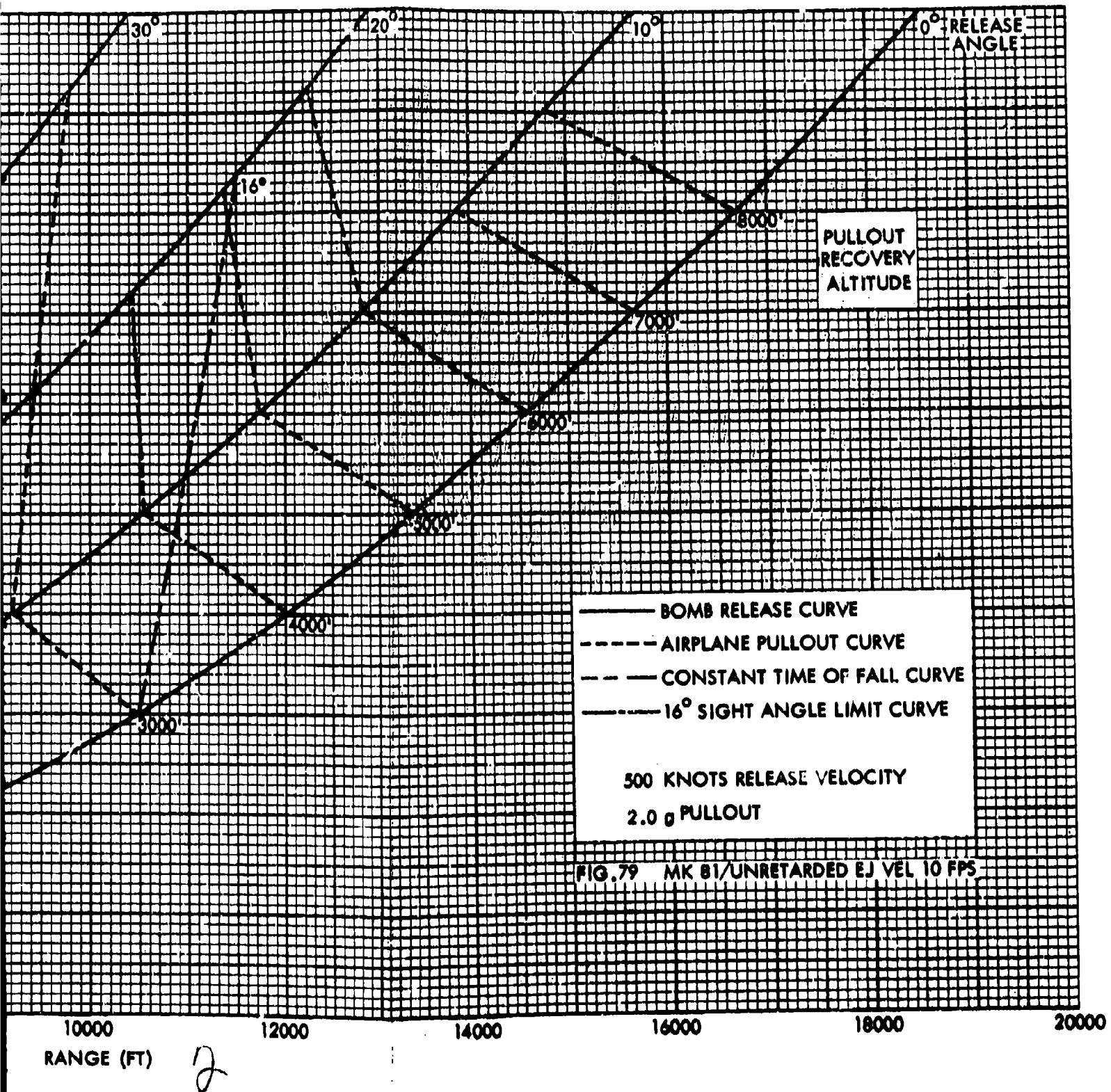
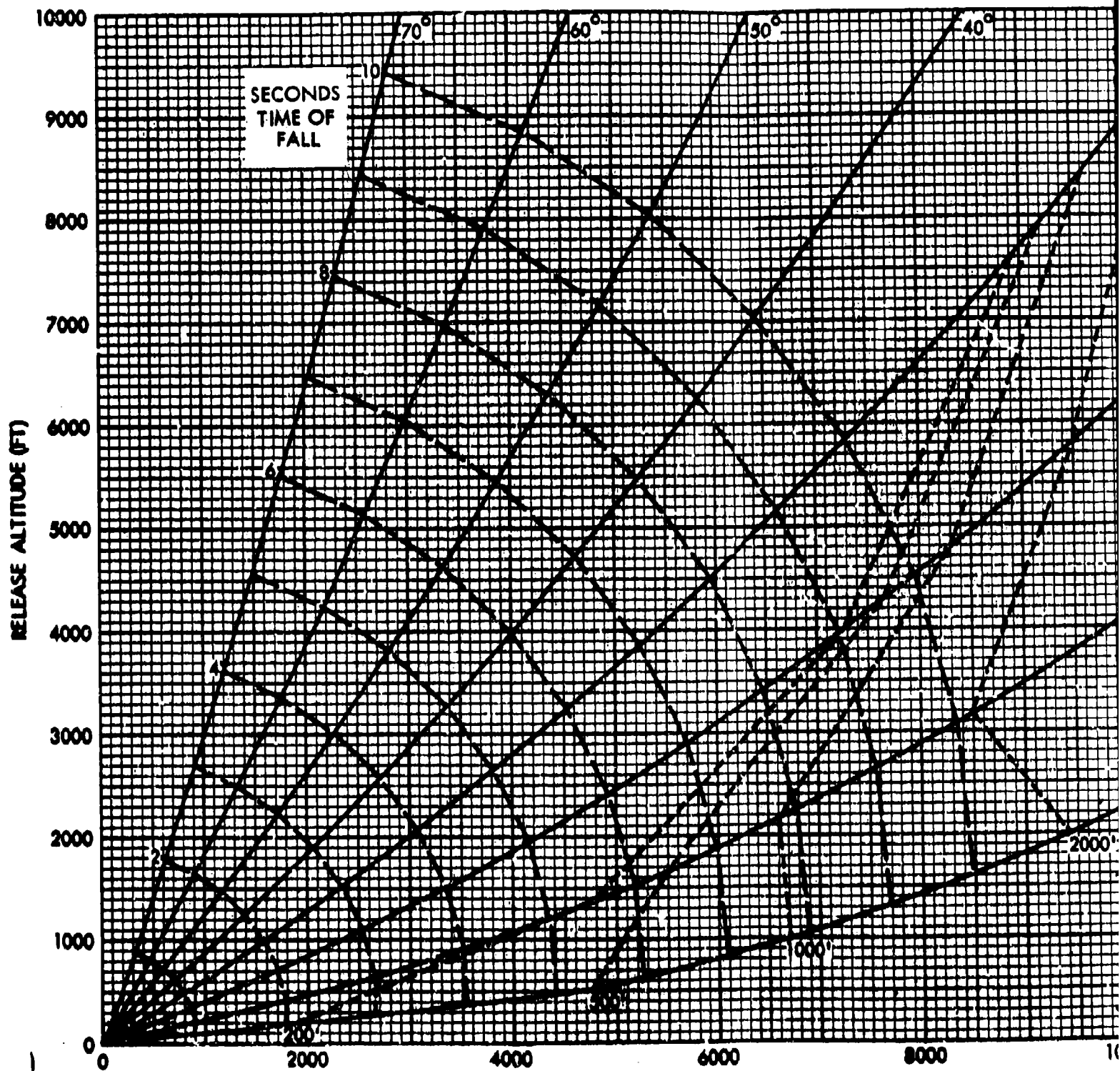


FIG. 78 MK 81 UNRETARDED EJ VEL 10 FPS







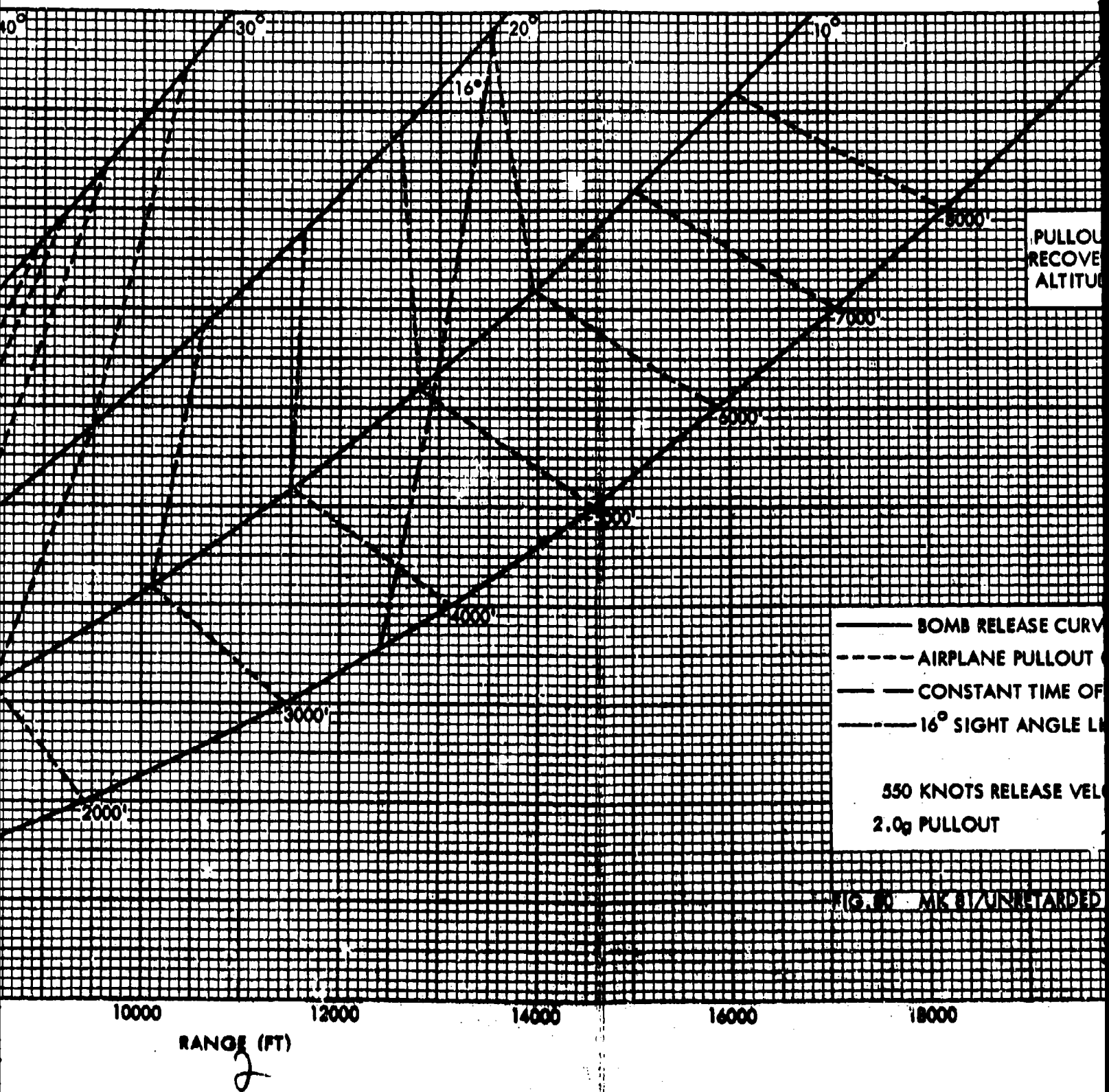
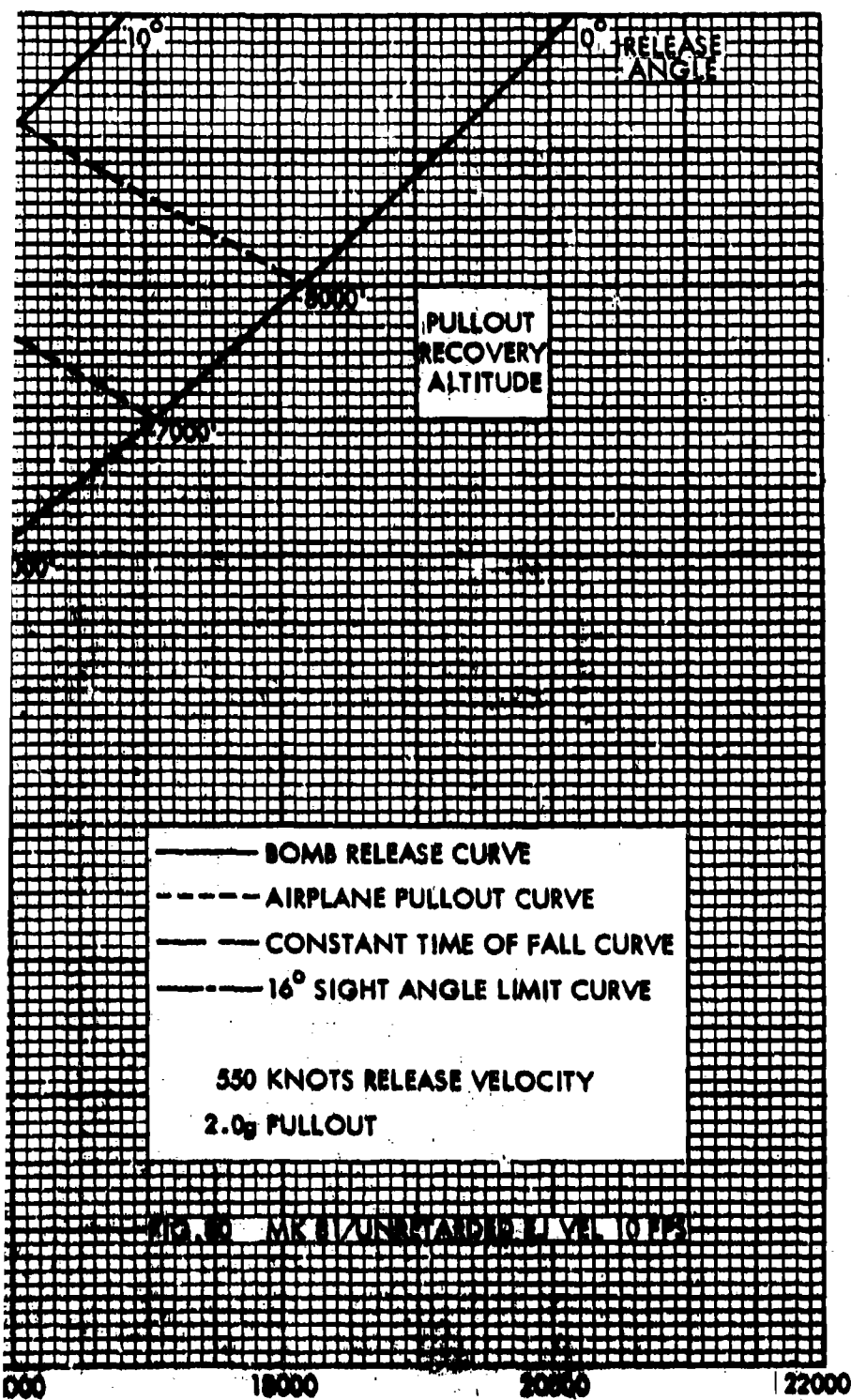
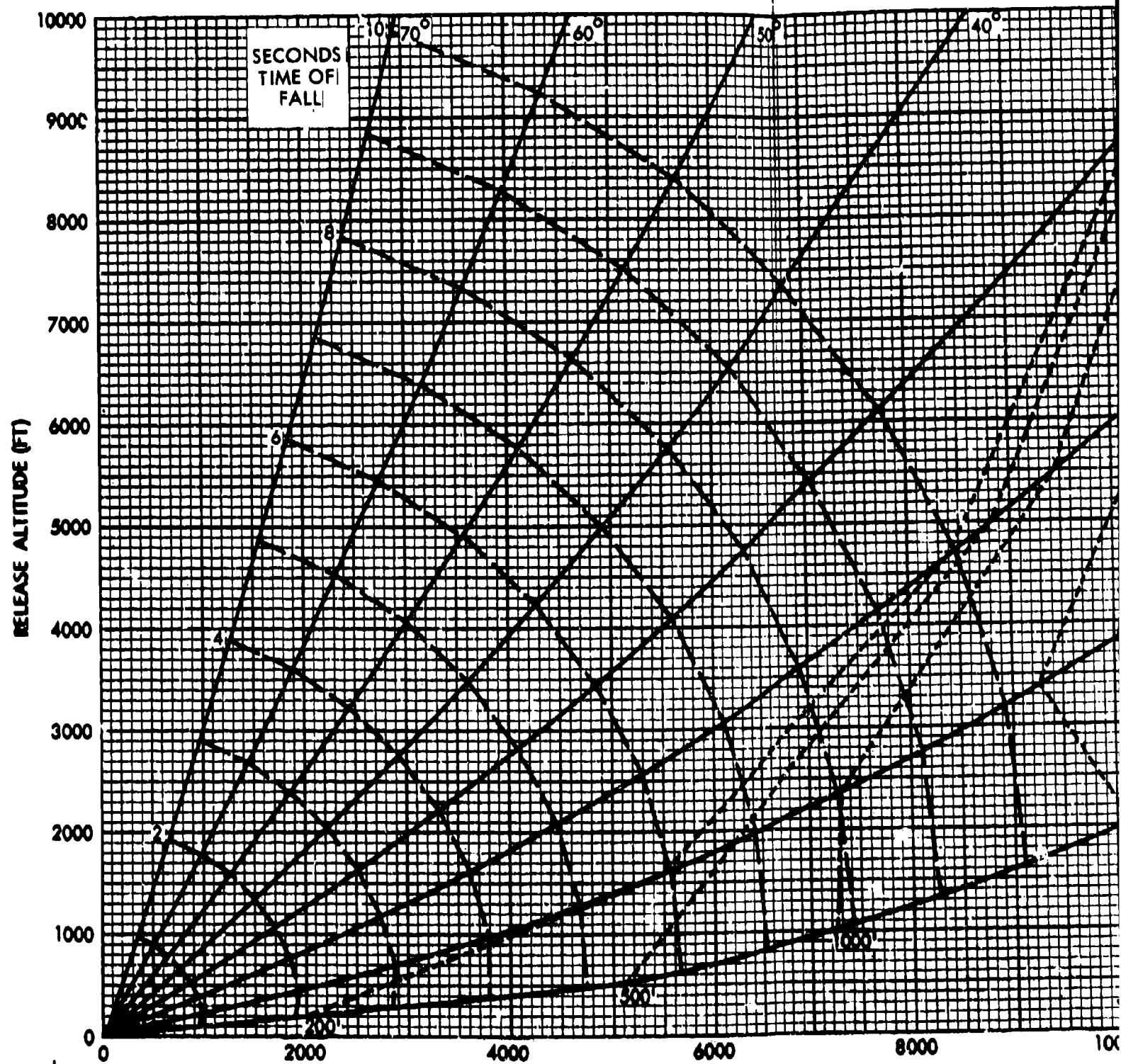


FIG. 10 MK 81 UNRETARDED





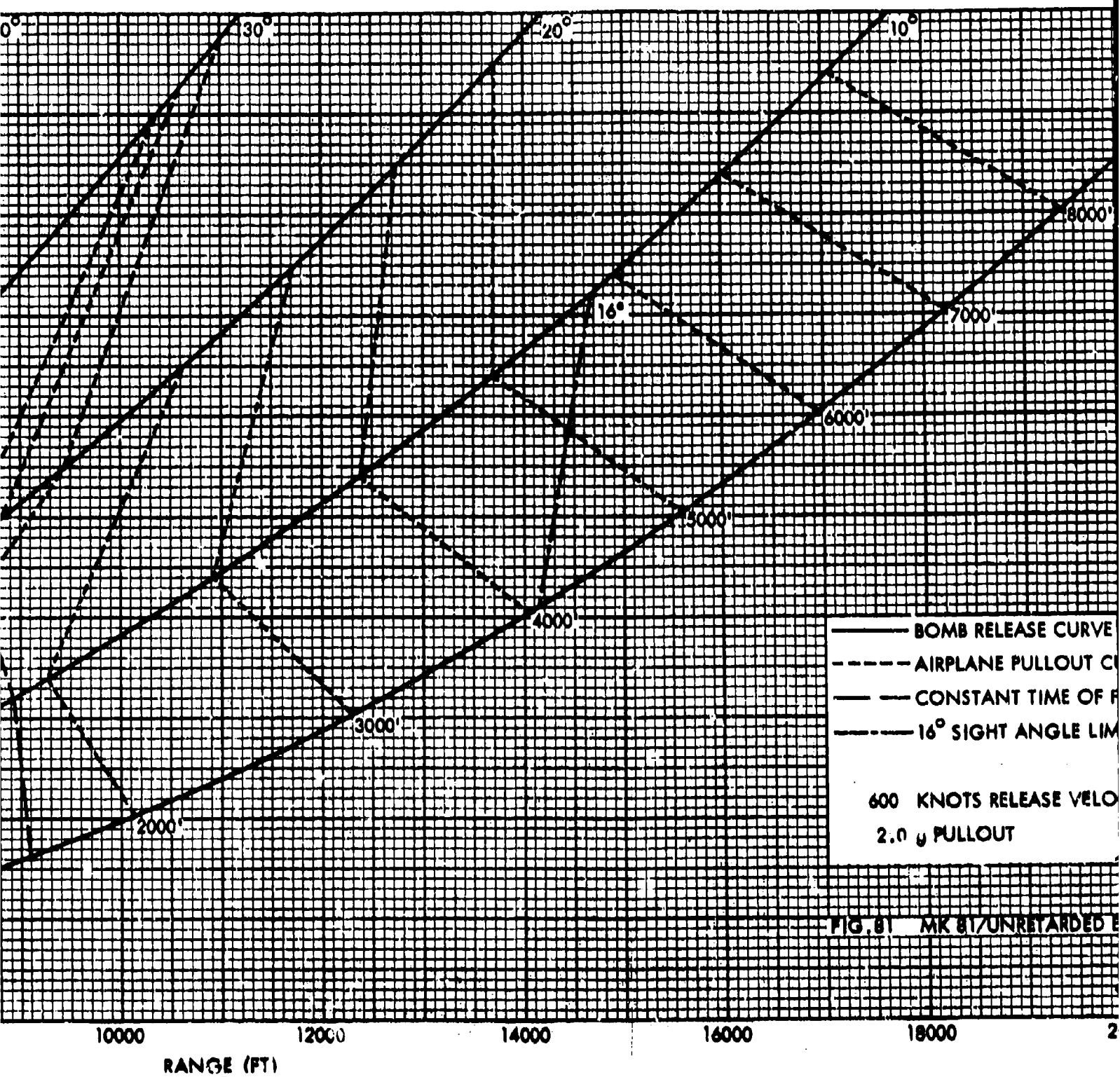
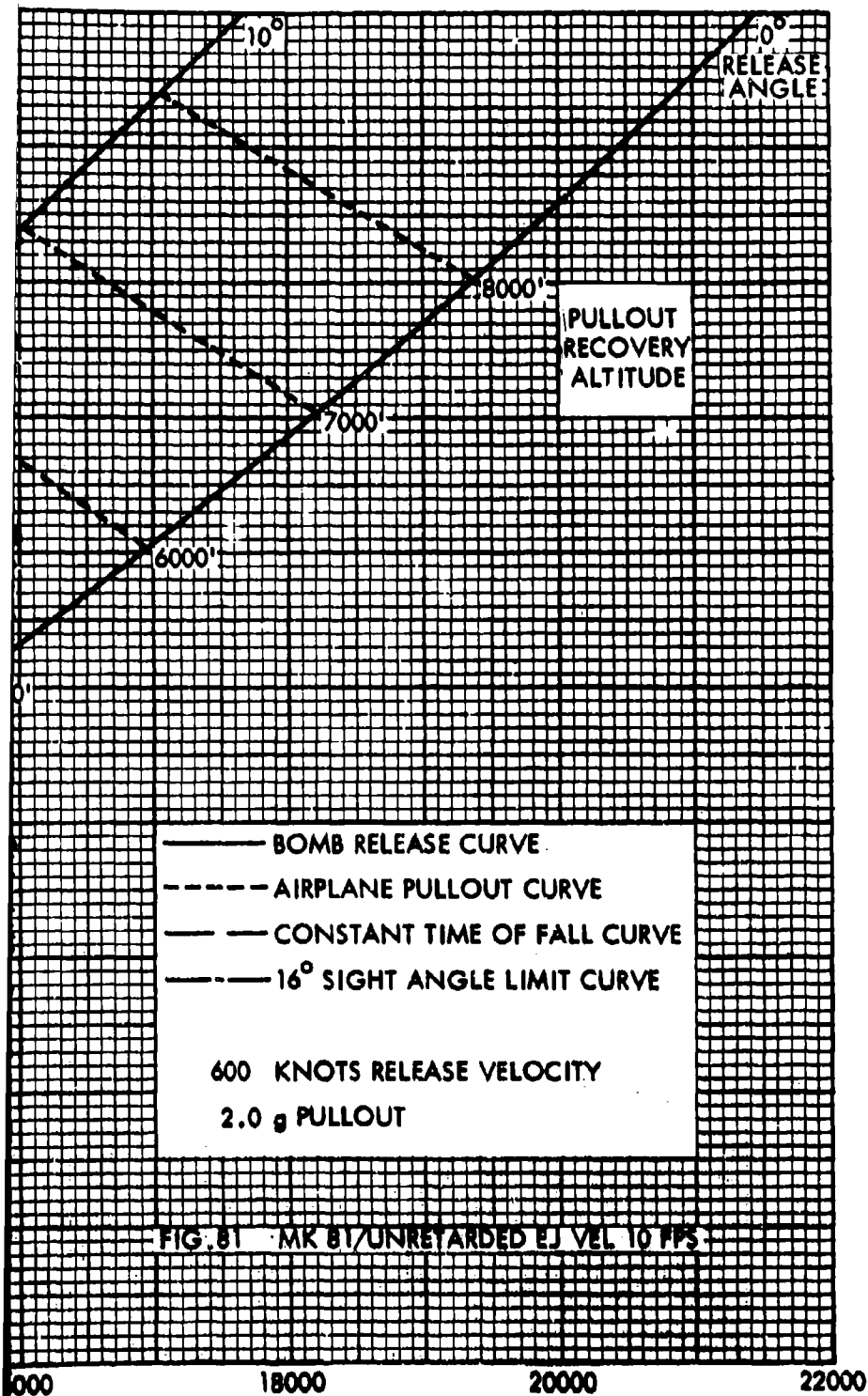


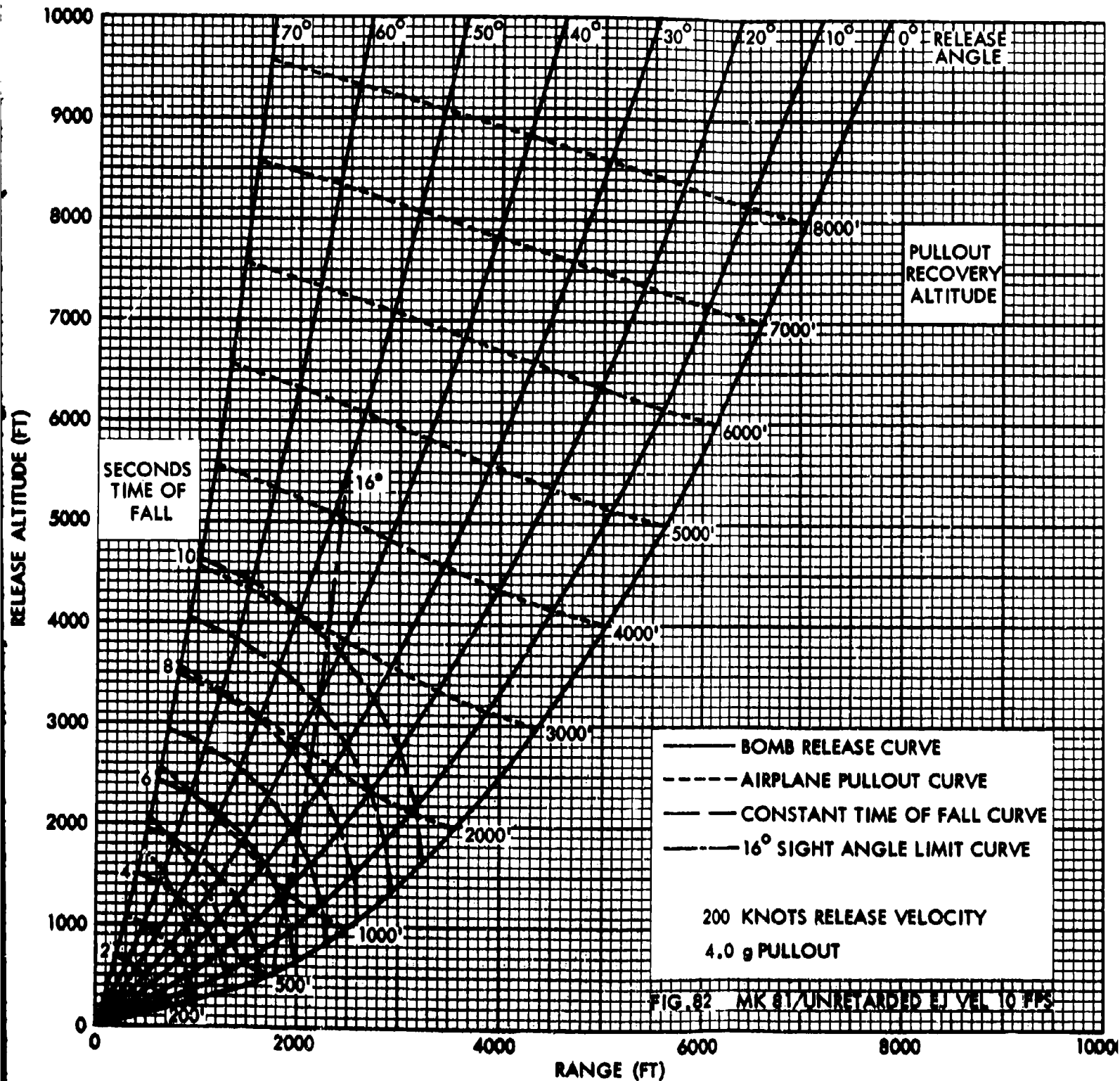
FIG. 81 MK 81/UNRETARDED

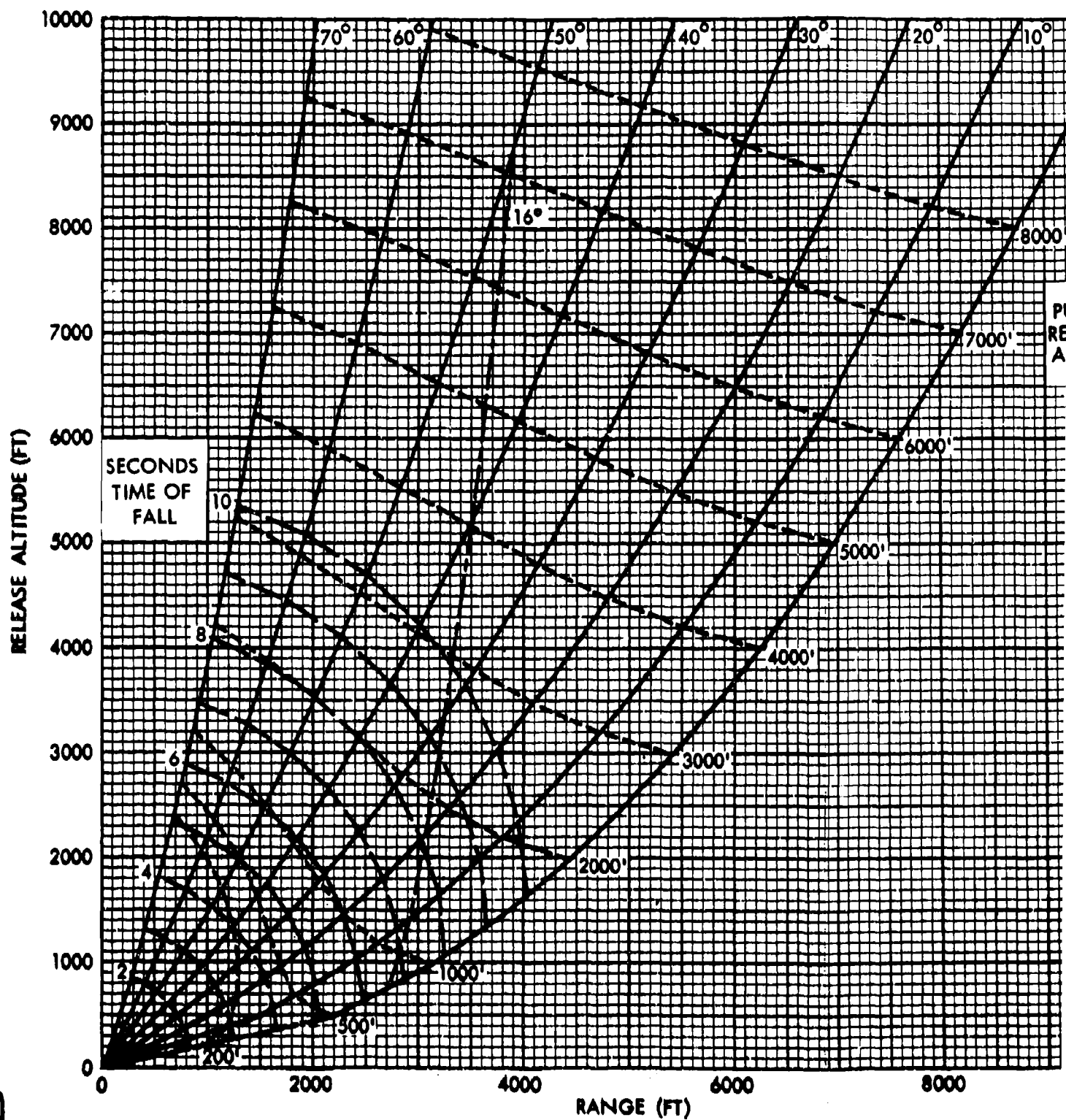
RANGE (FT)

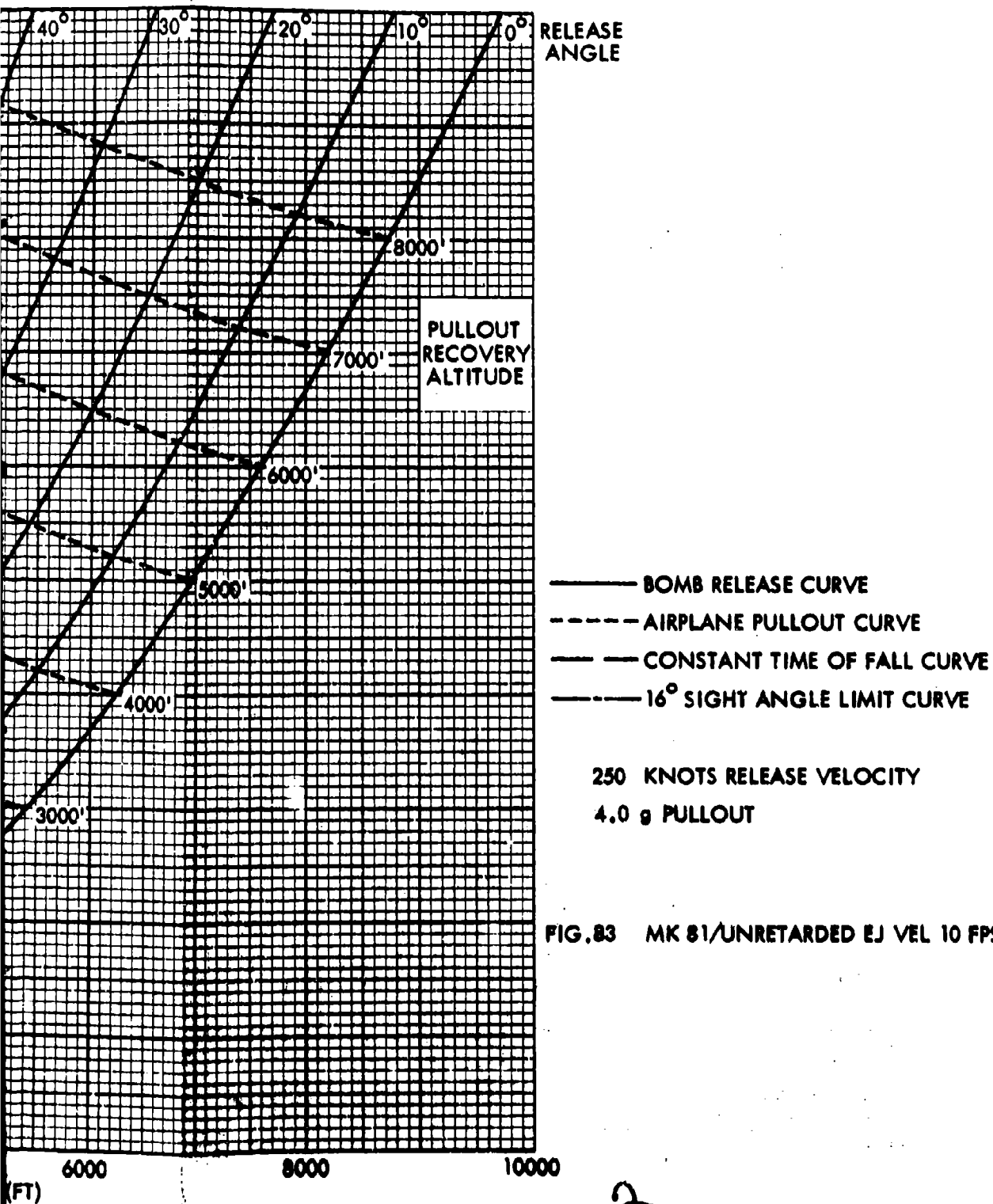
2

NOLTR 65-230

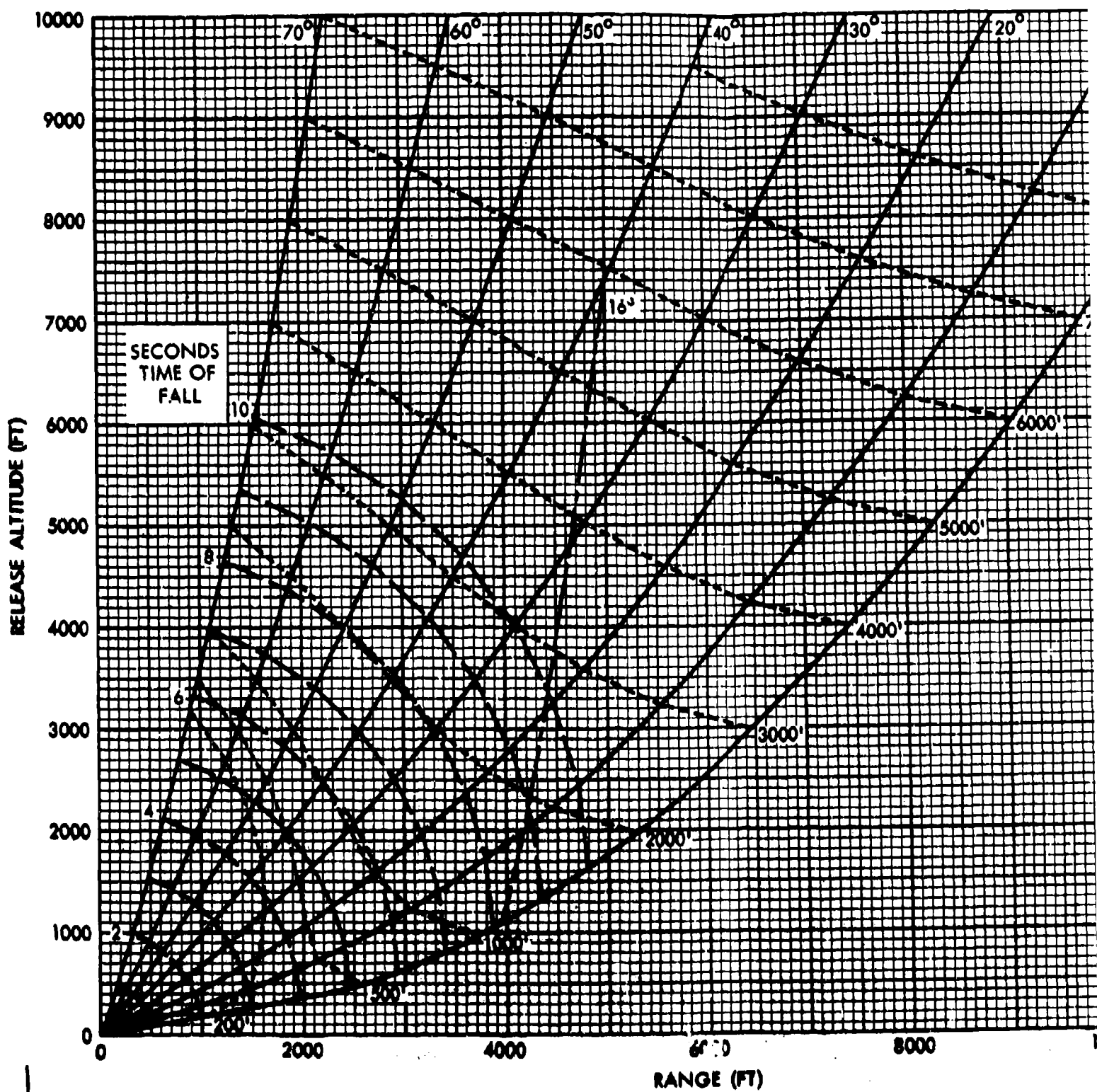


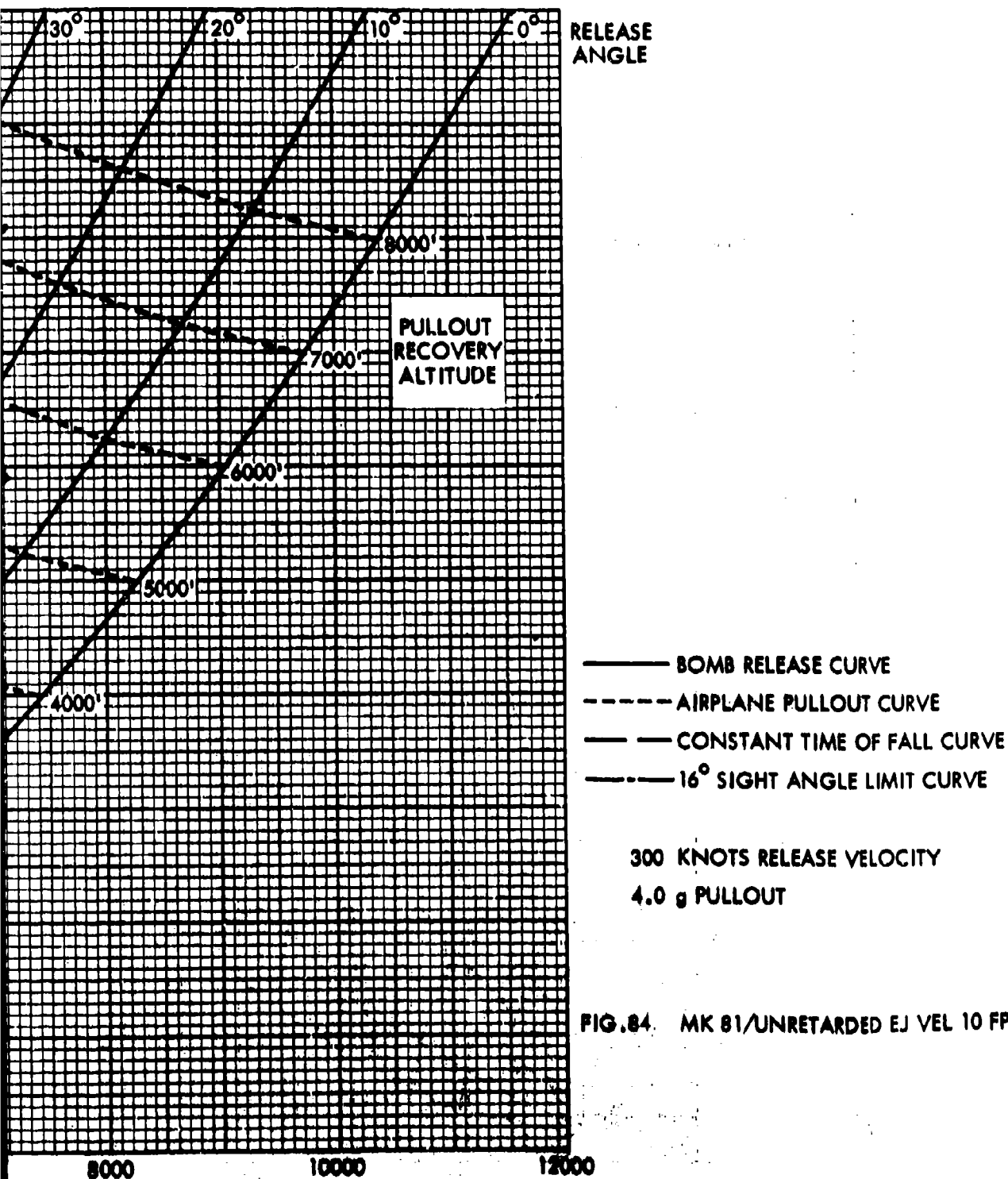


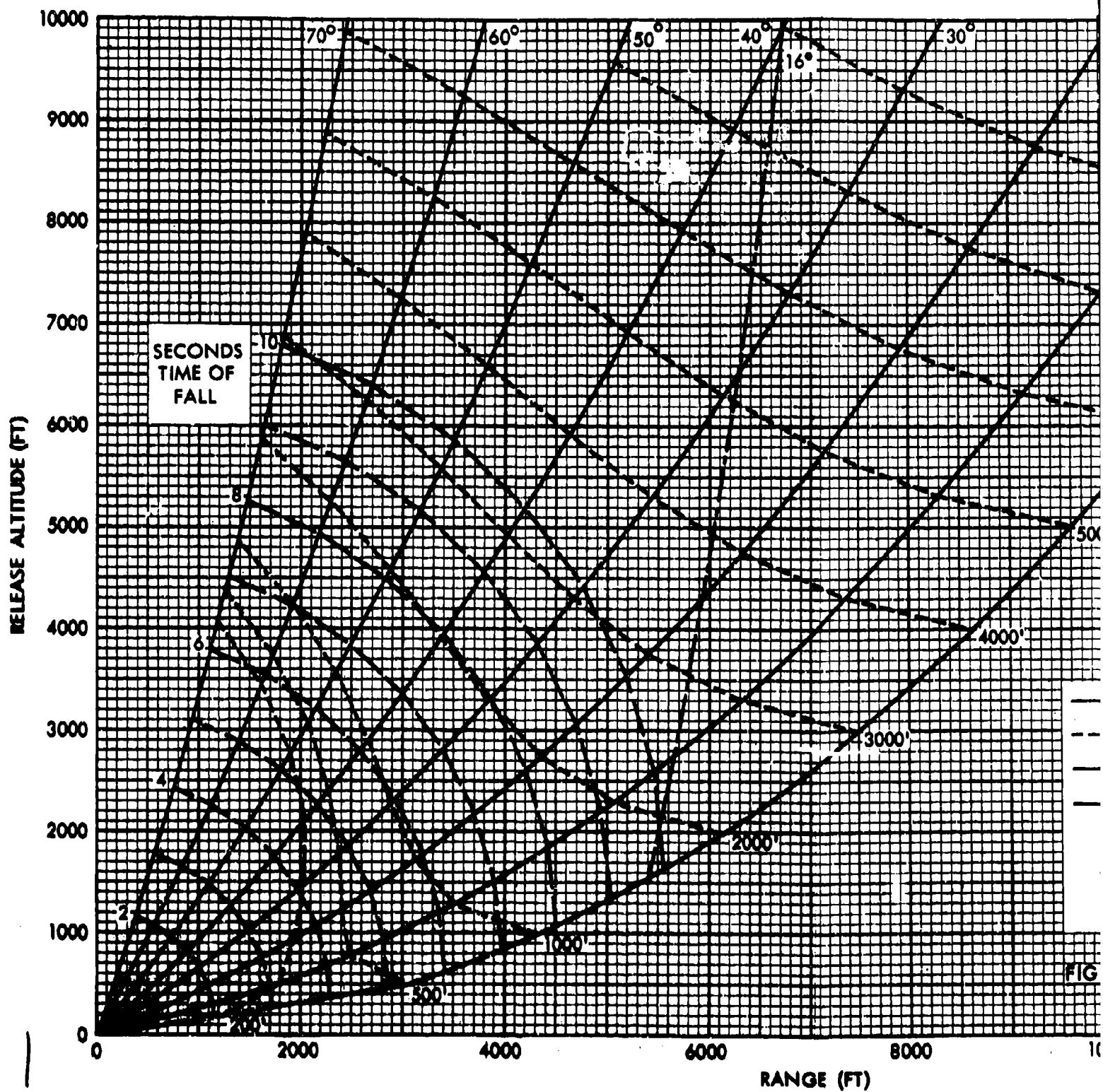


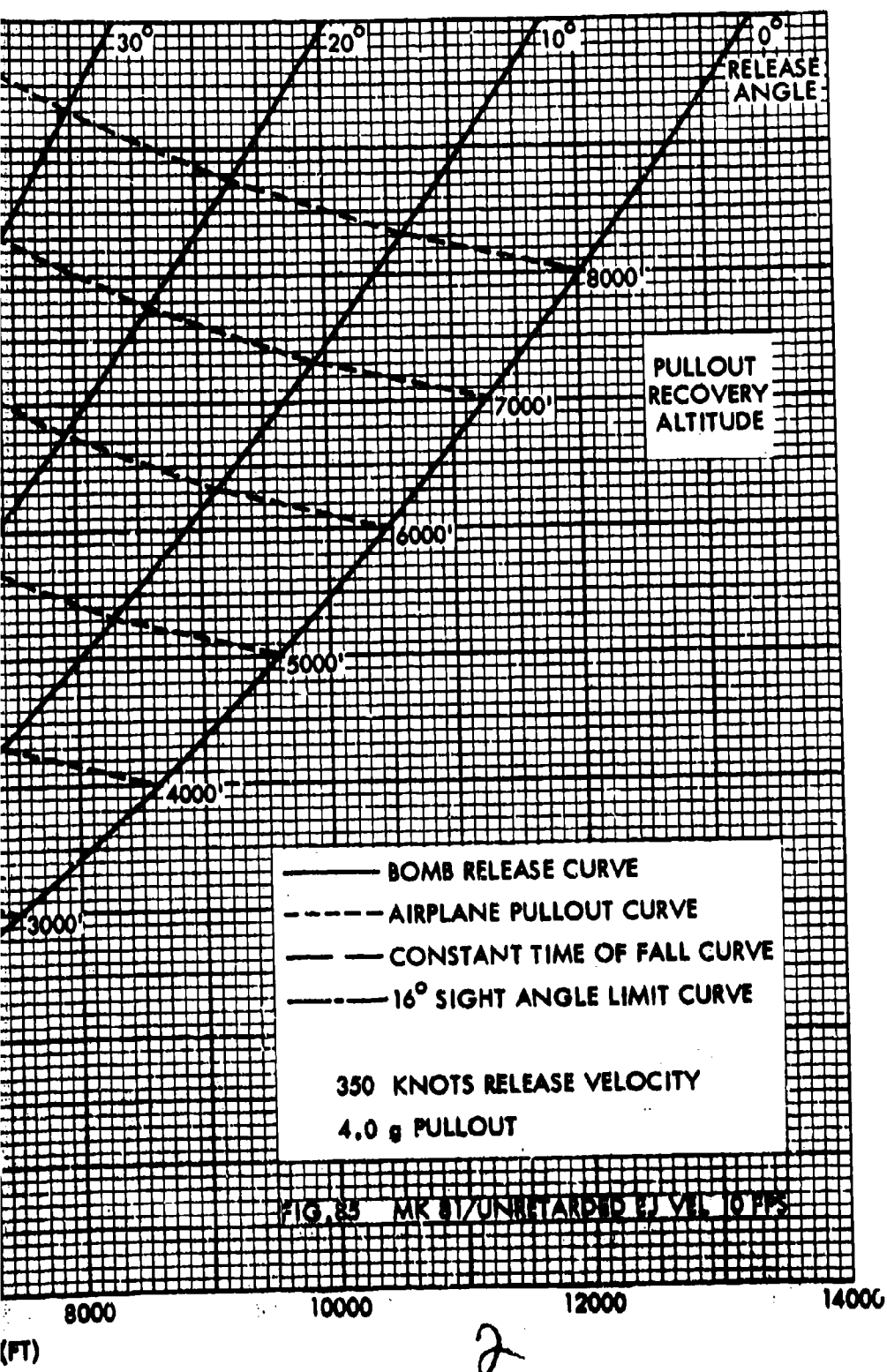


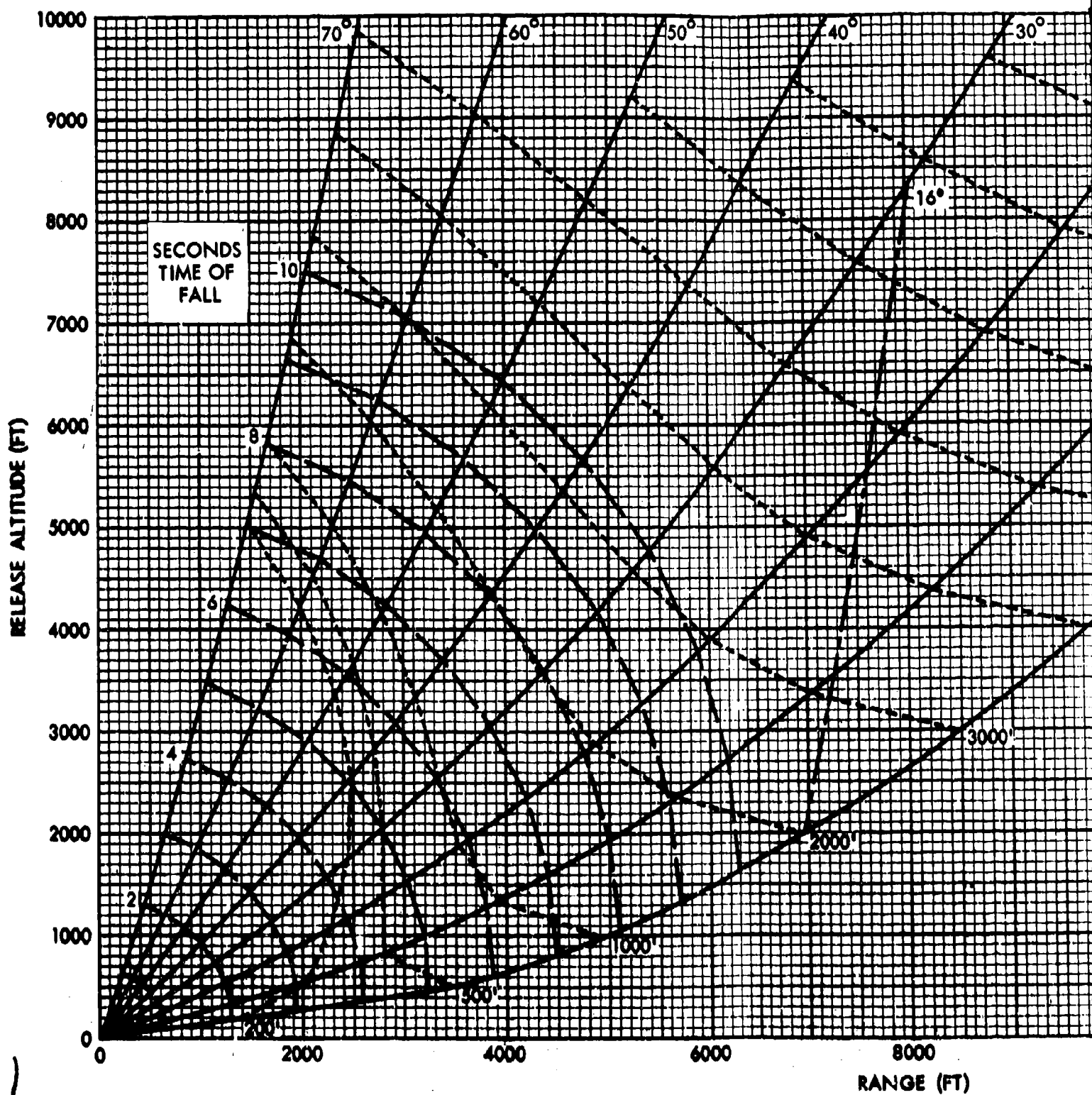
2

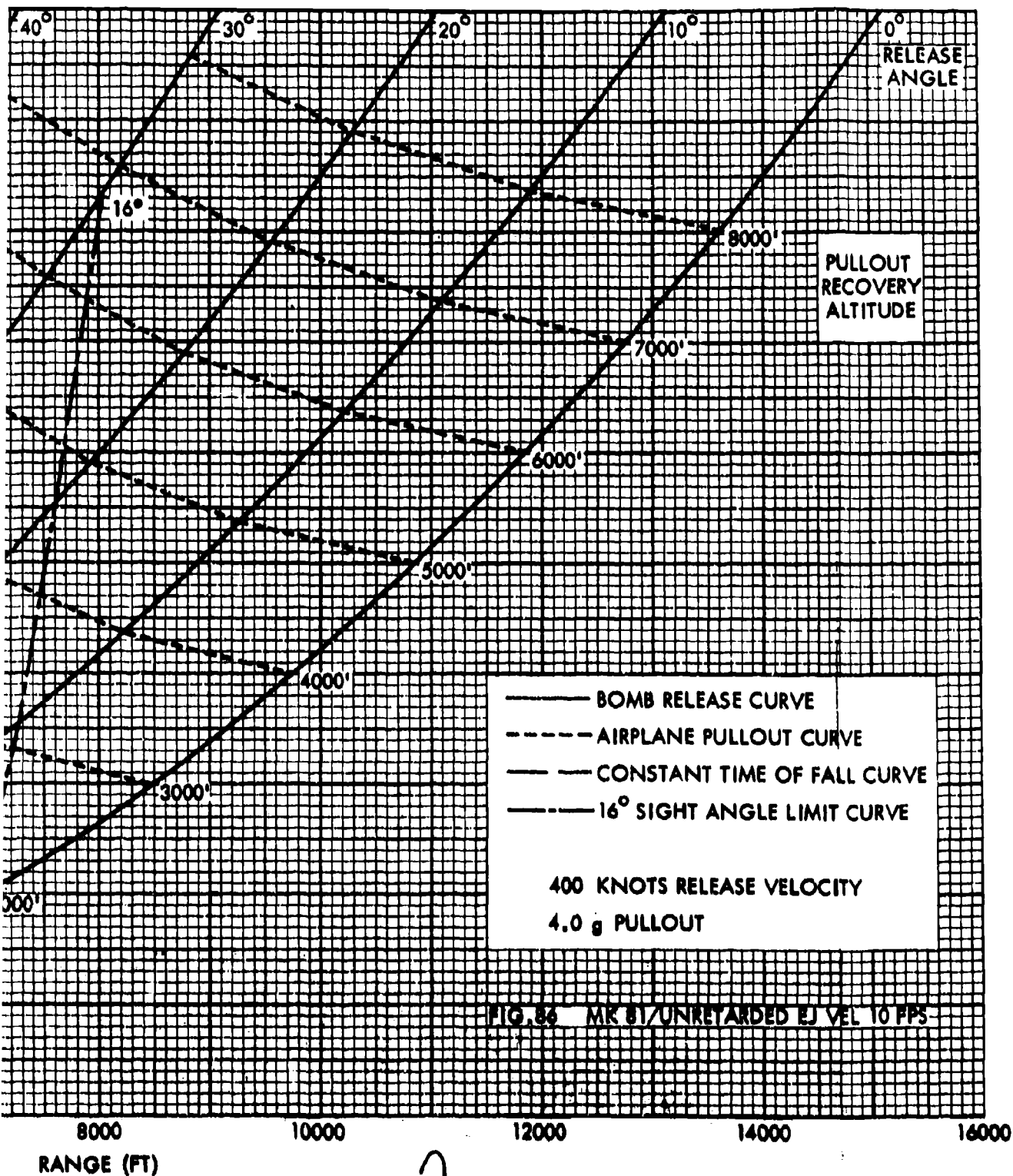


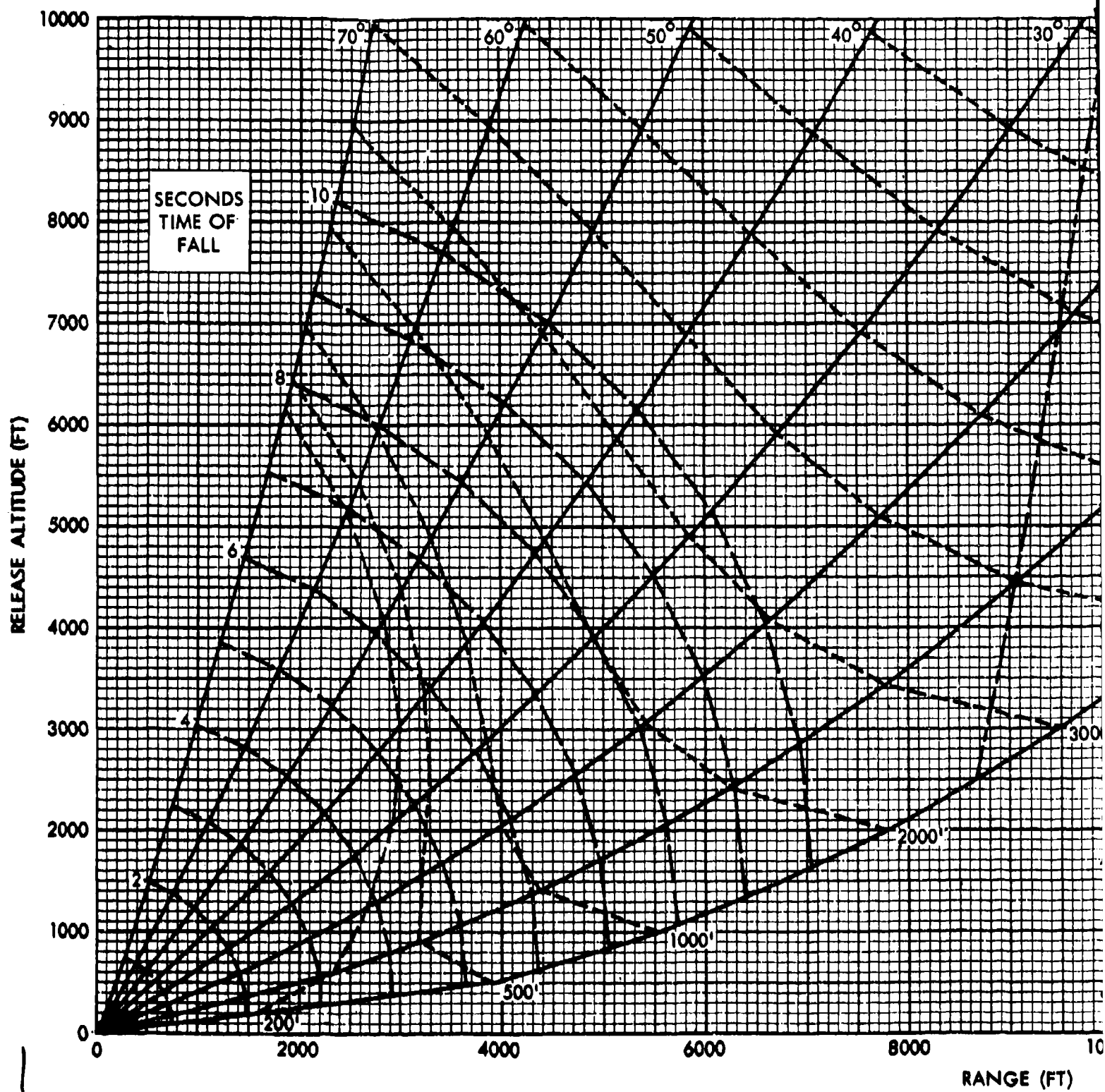


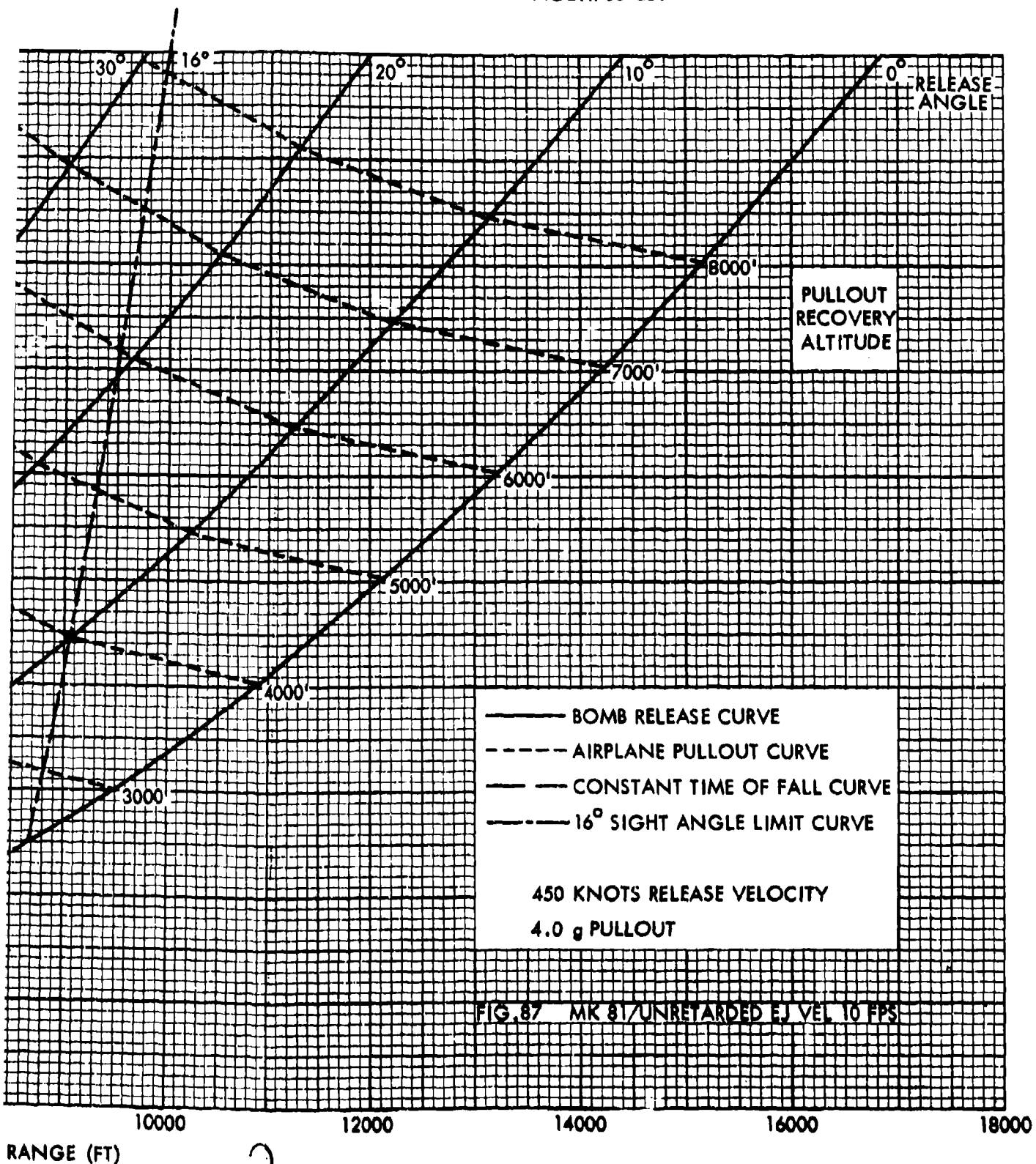


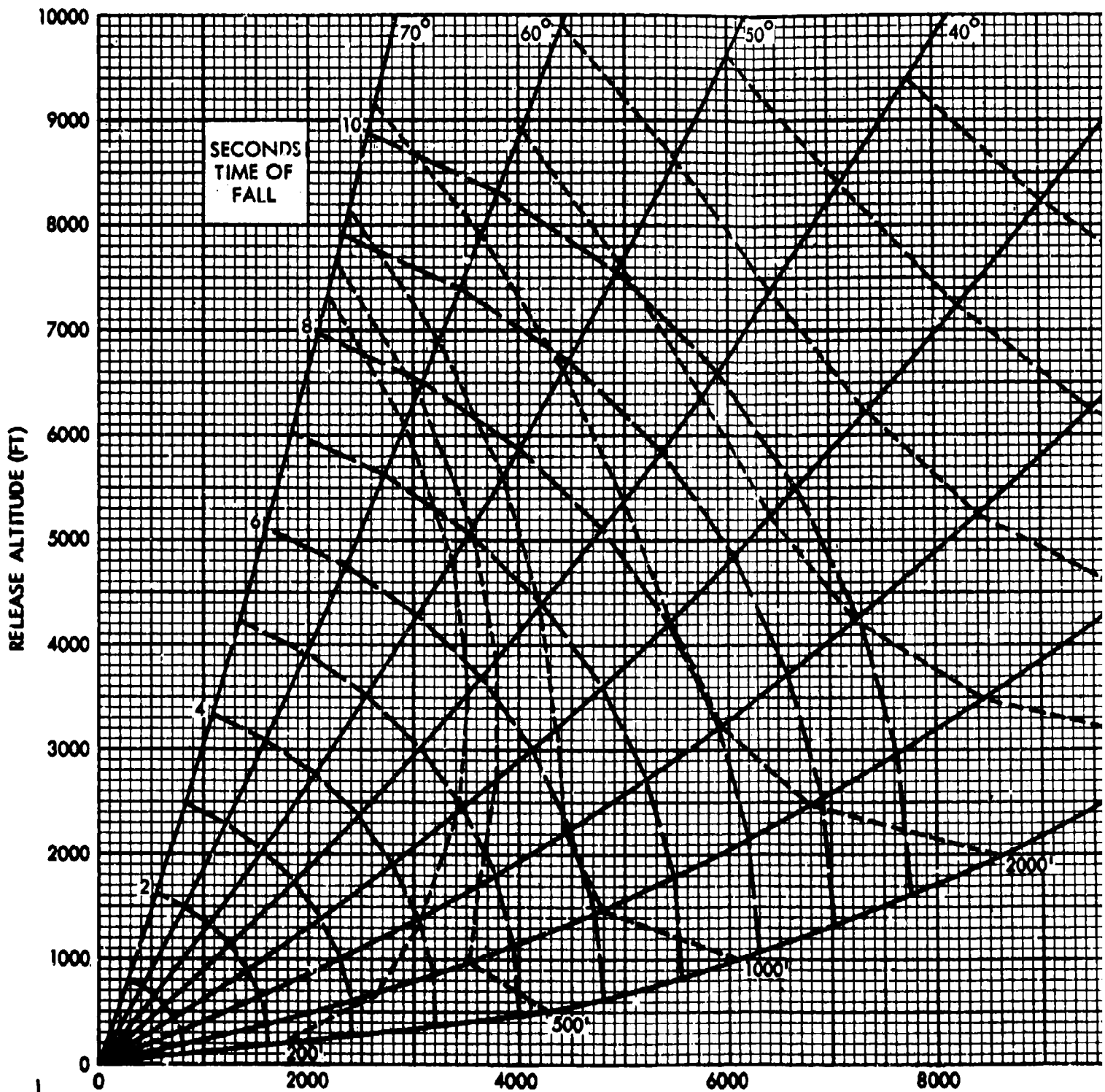




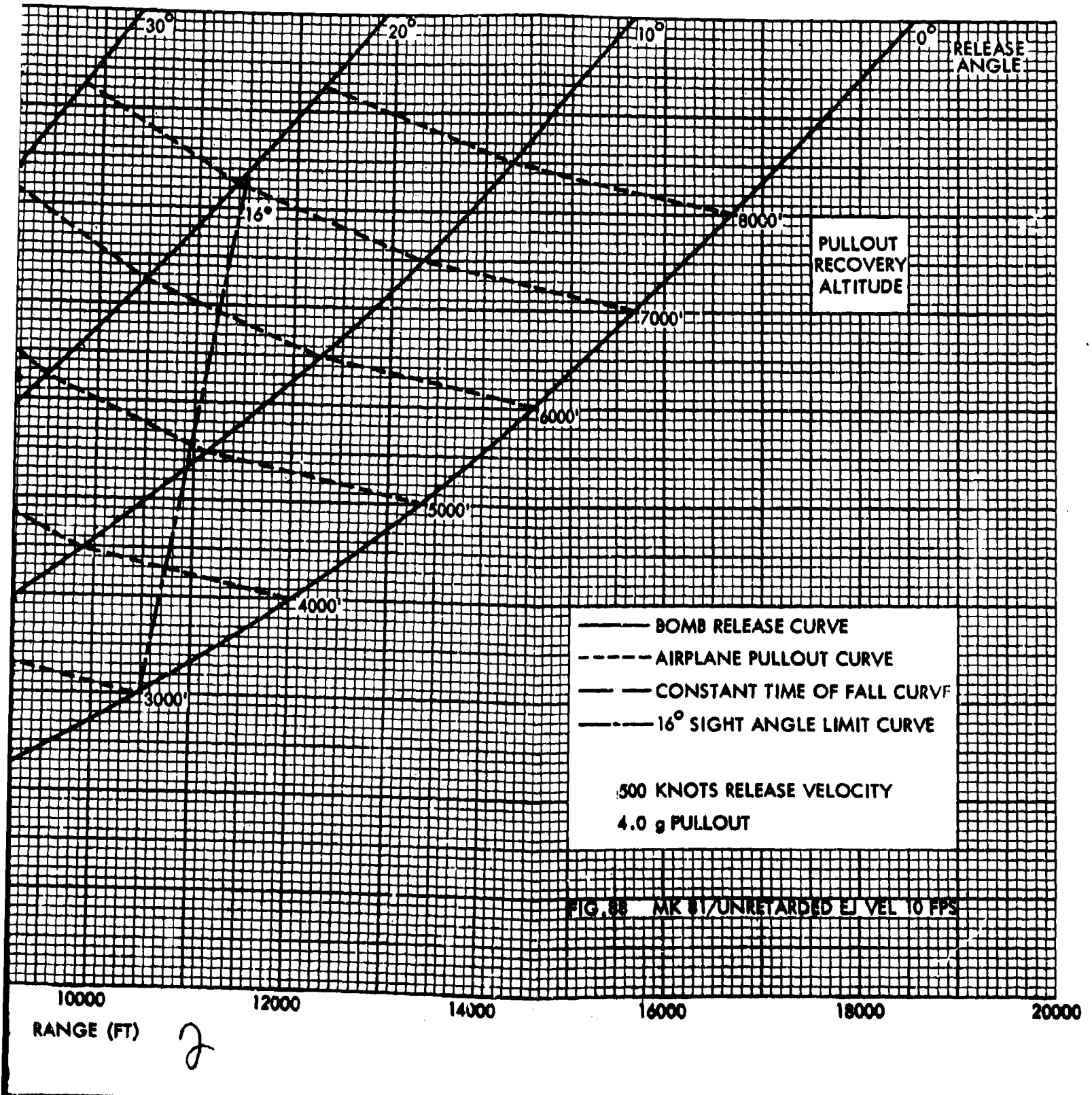


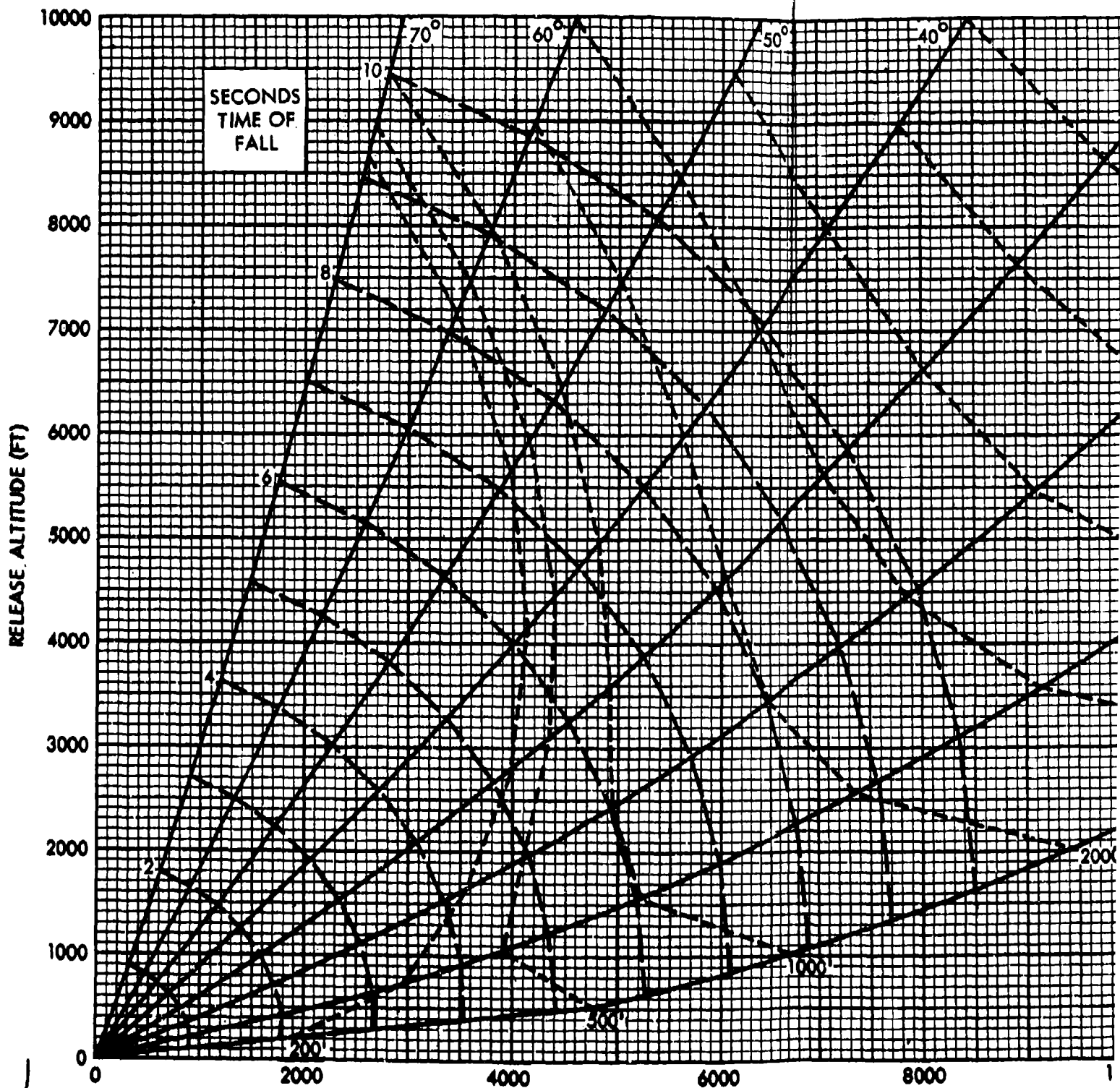


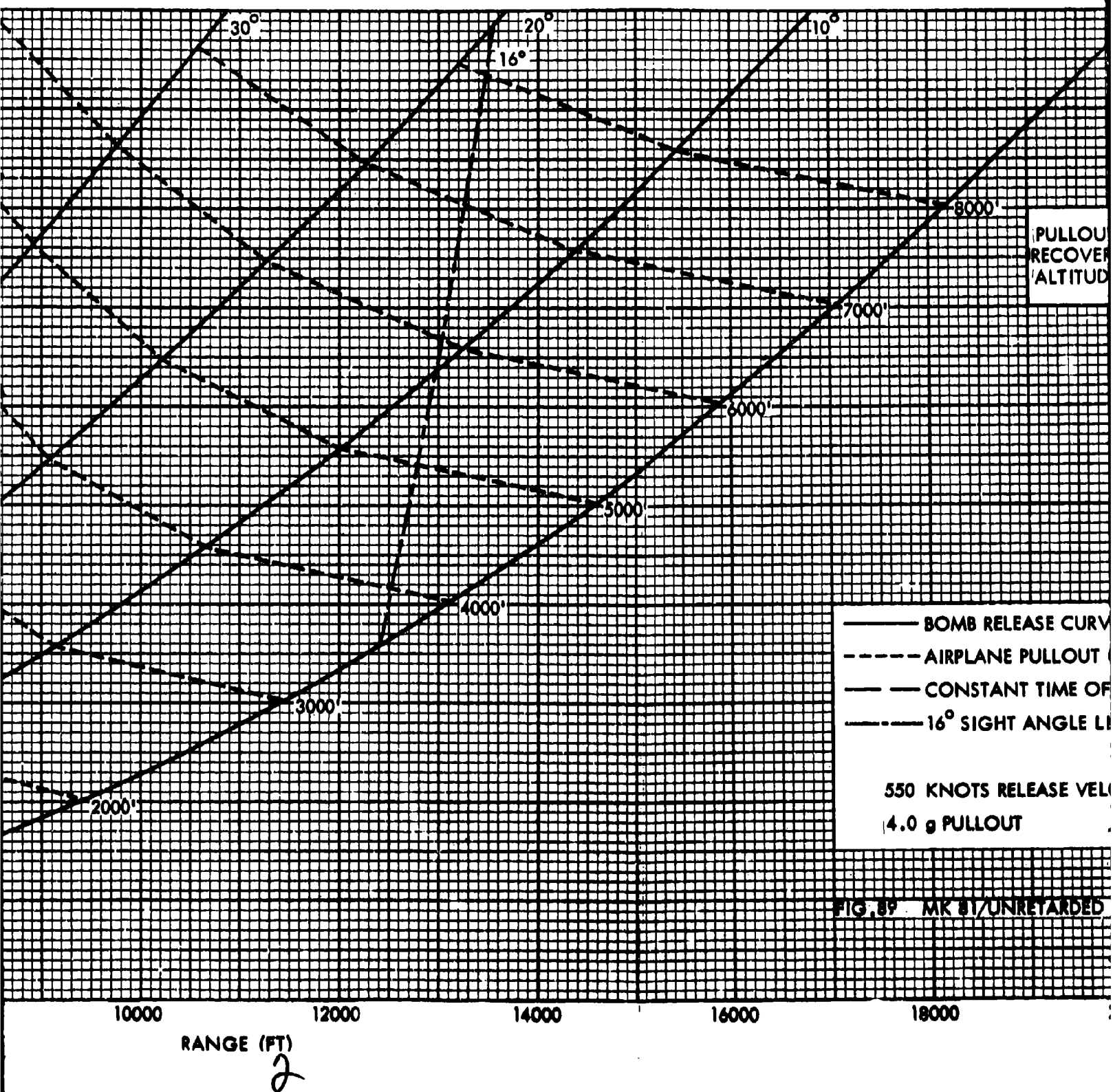




NOLTR 65-230







NOLTR 65-230

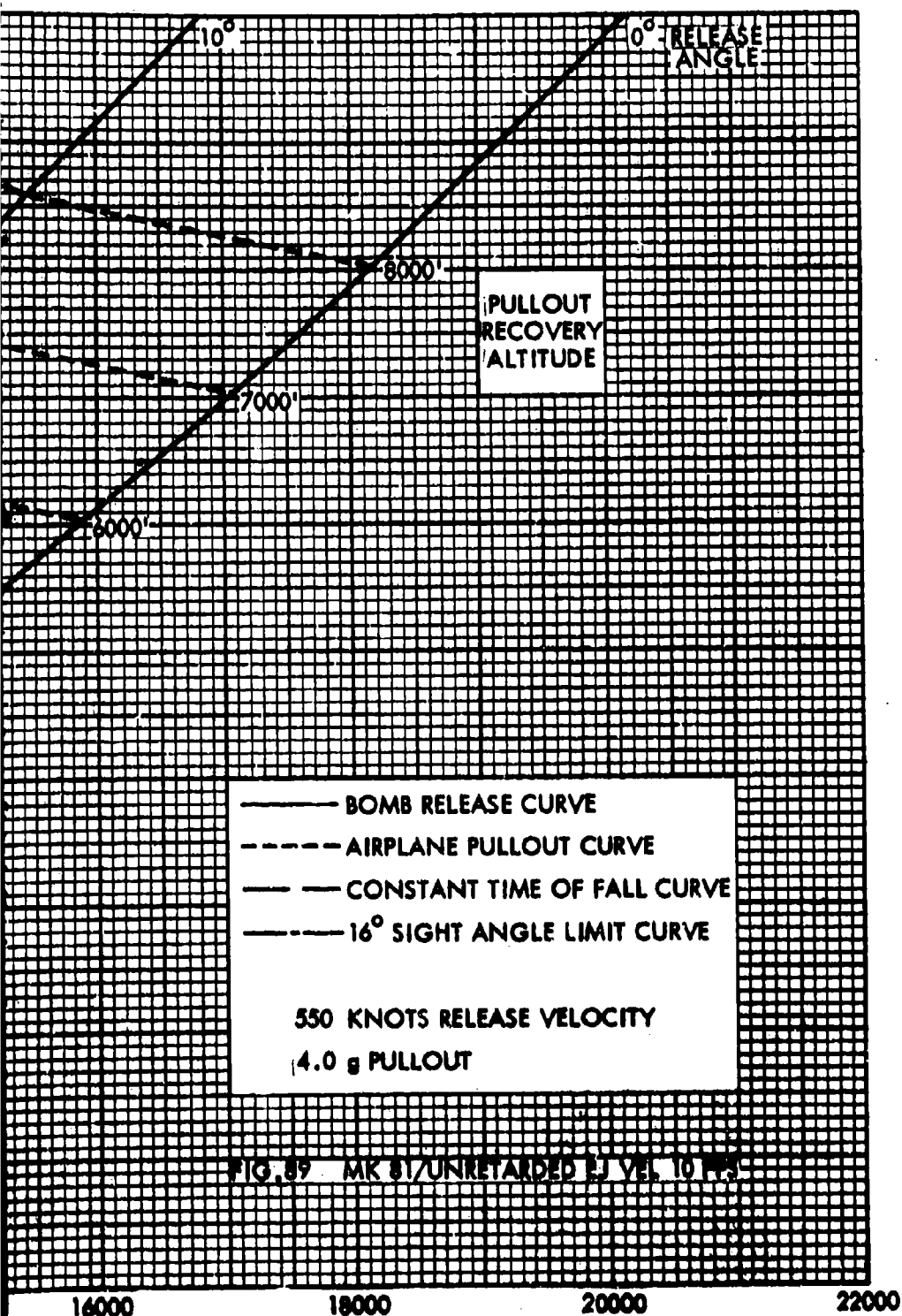
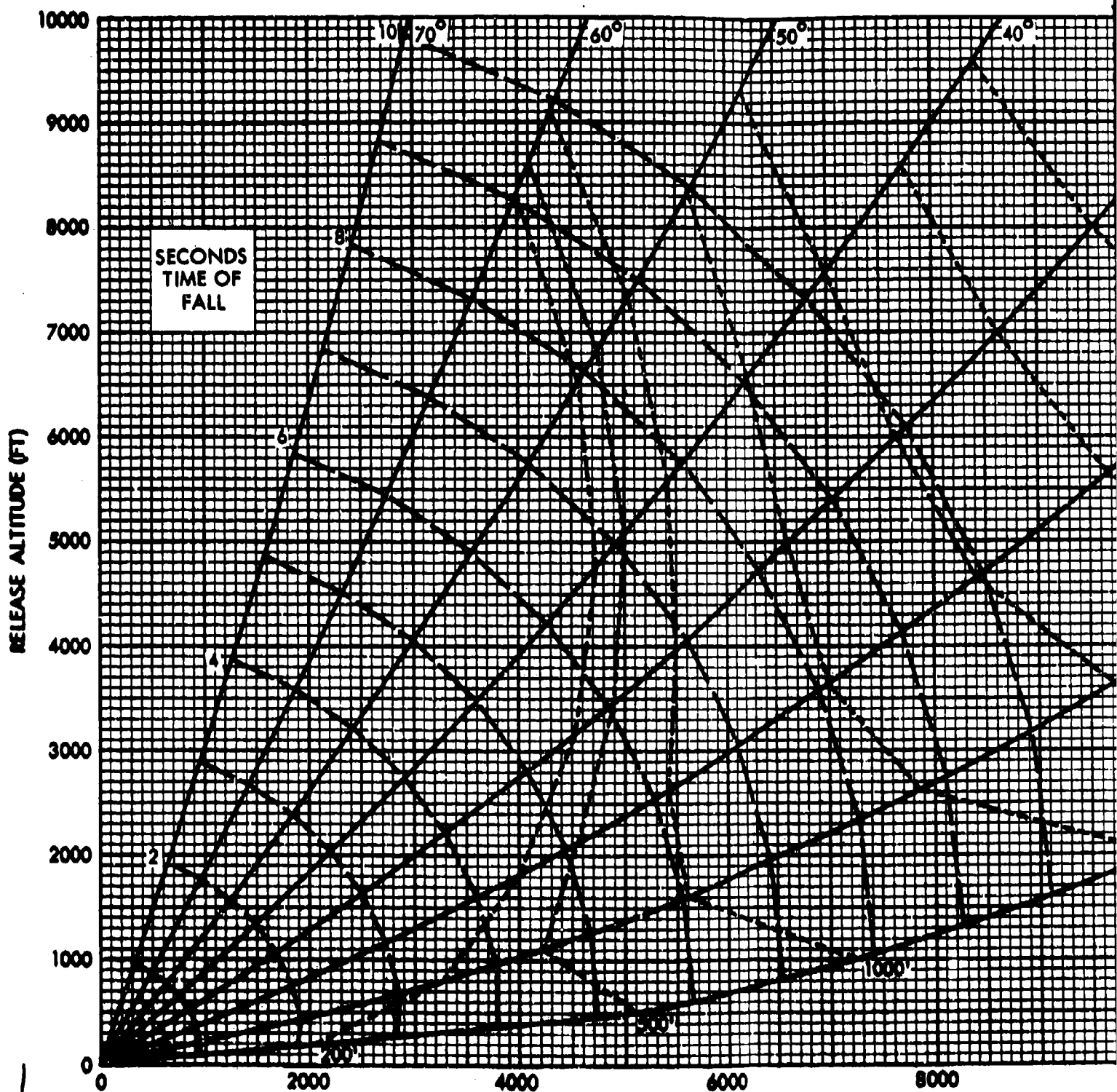


FIG. 89 MK 81/UNRETARDED EJ VEL 10 FPS



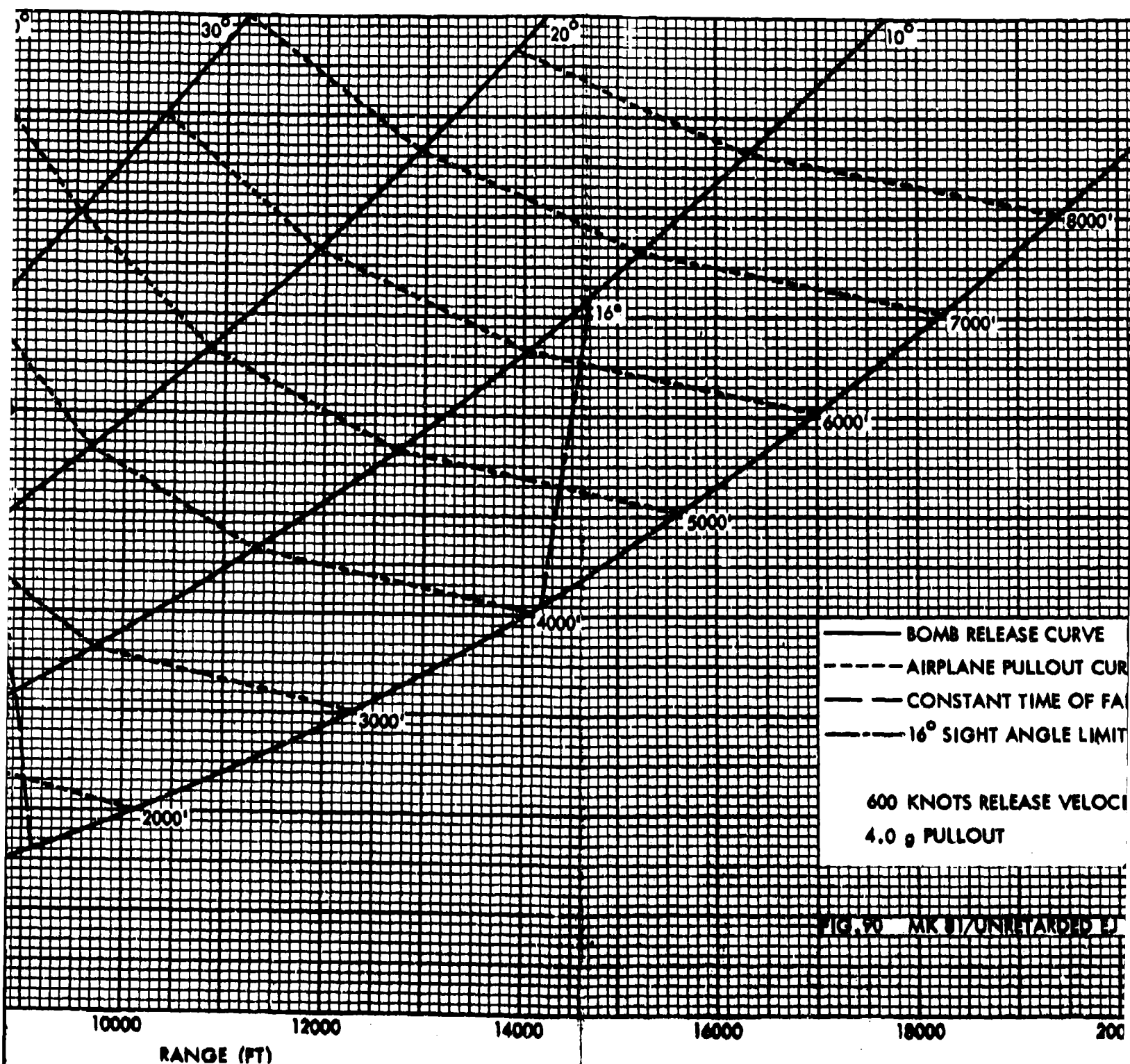


FIG. 90 MK 81/UNRETARDED E

RANGE (FT)

2

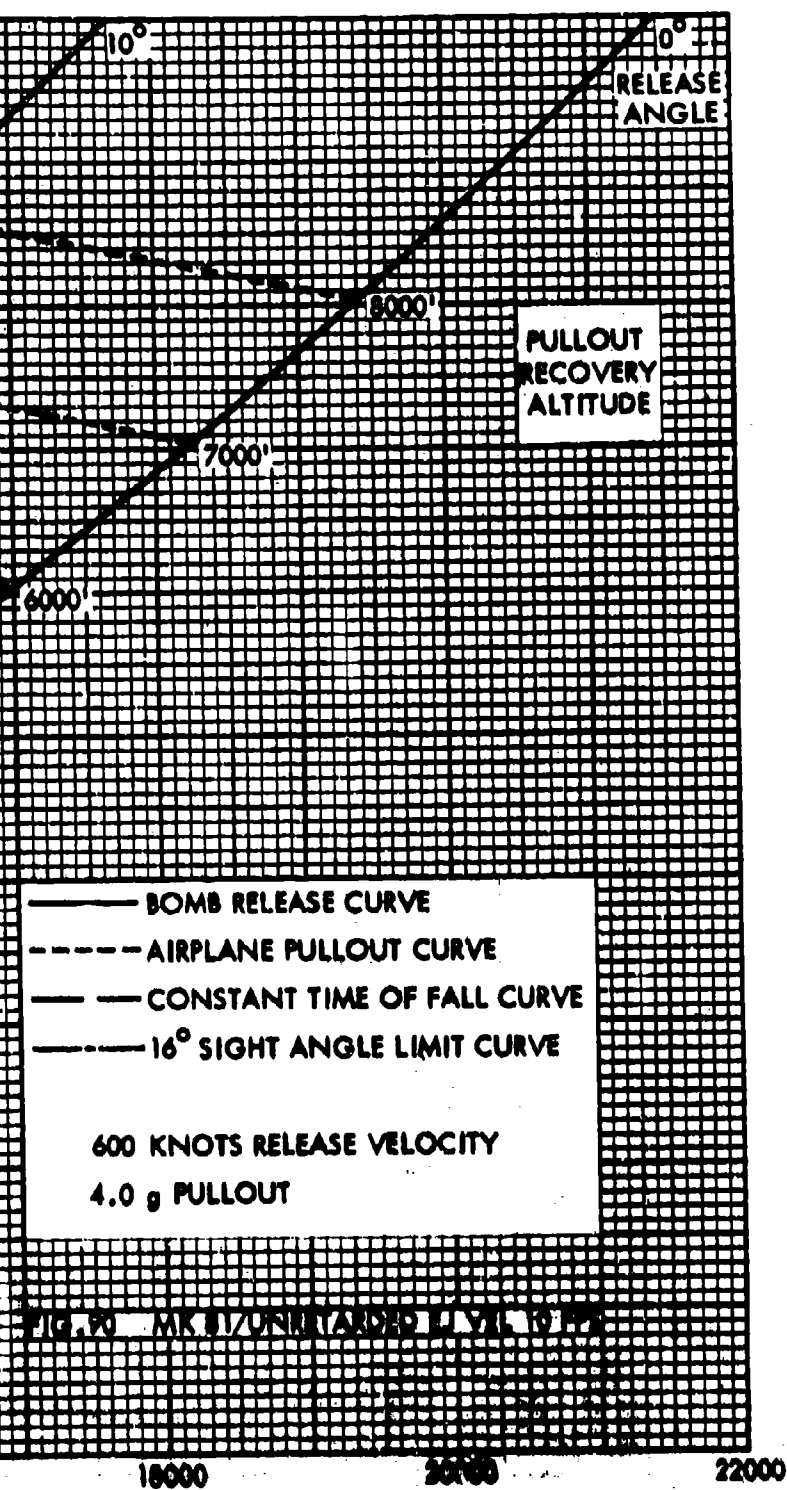
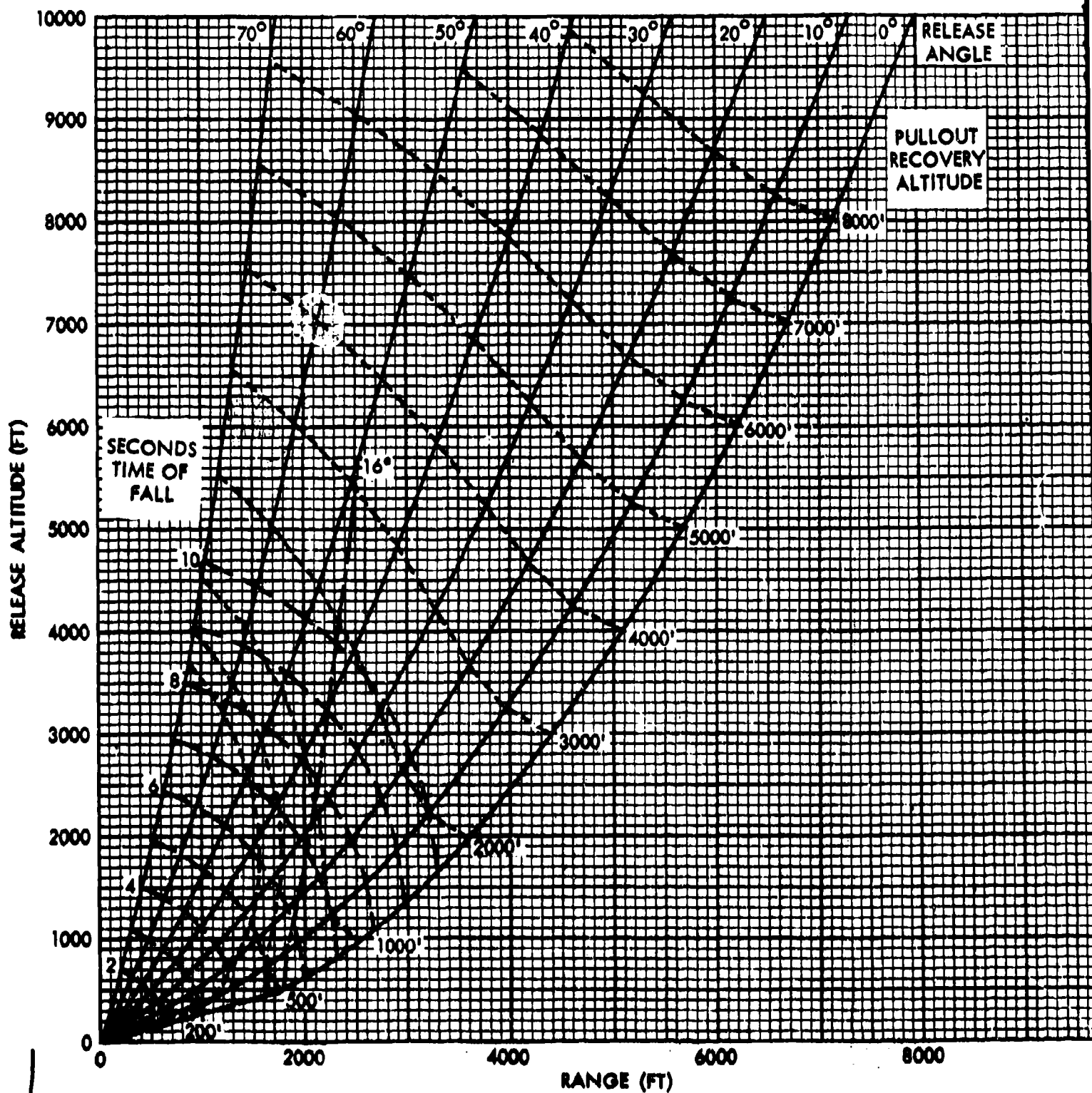
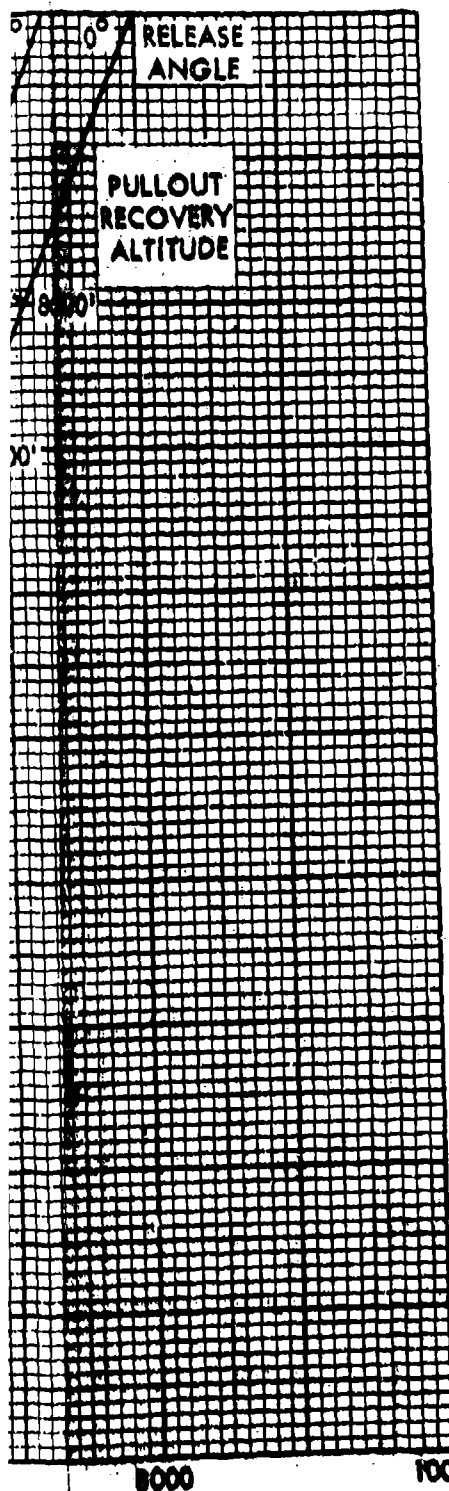


FIG. 90 MK 81/UNRETARDED LEVEL 10 FPS



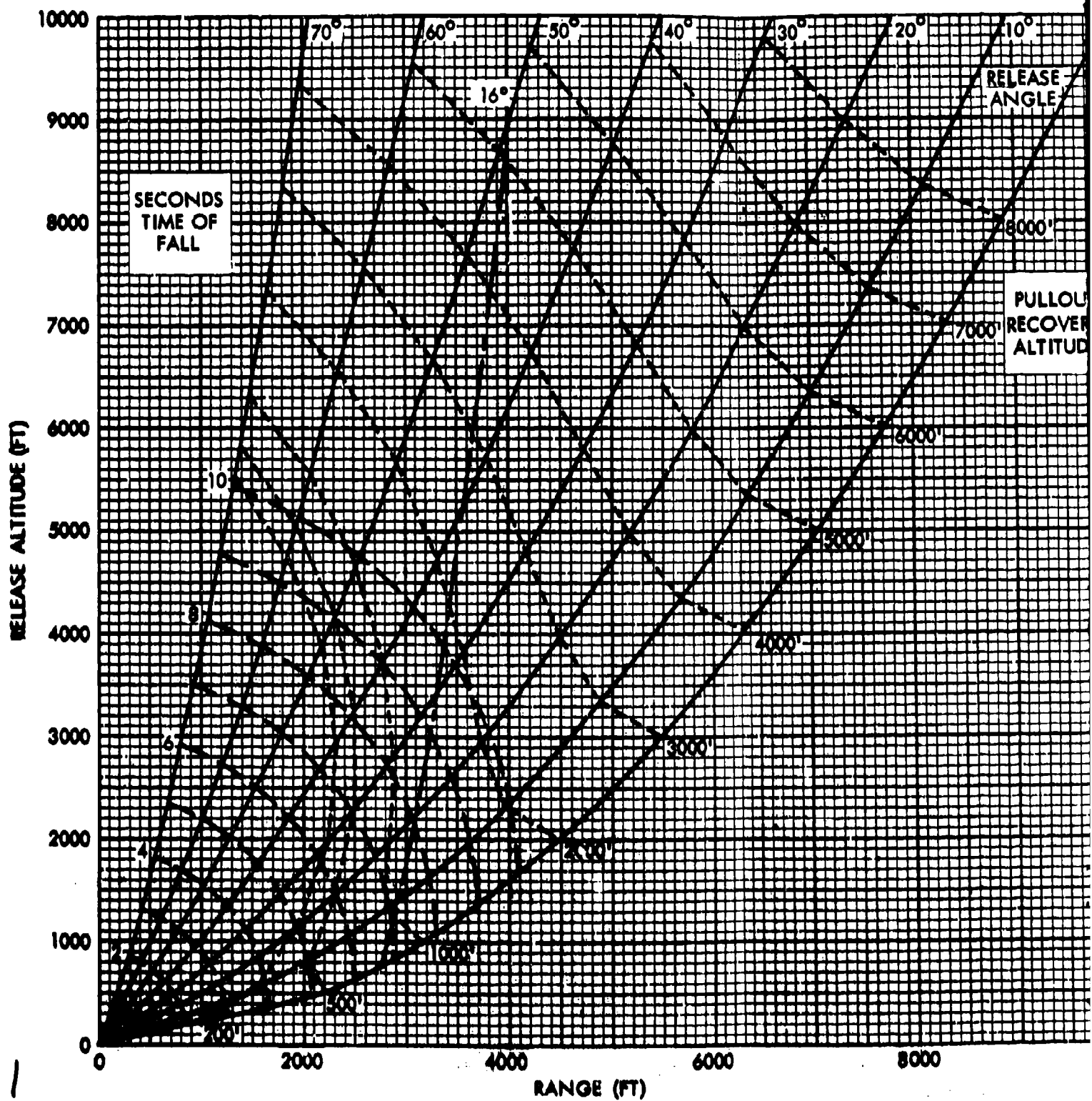
NOLTR 65-230



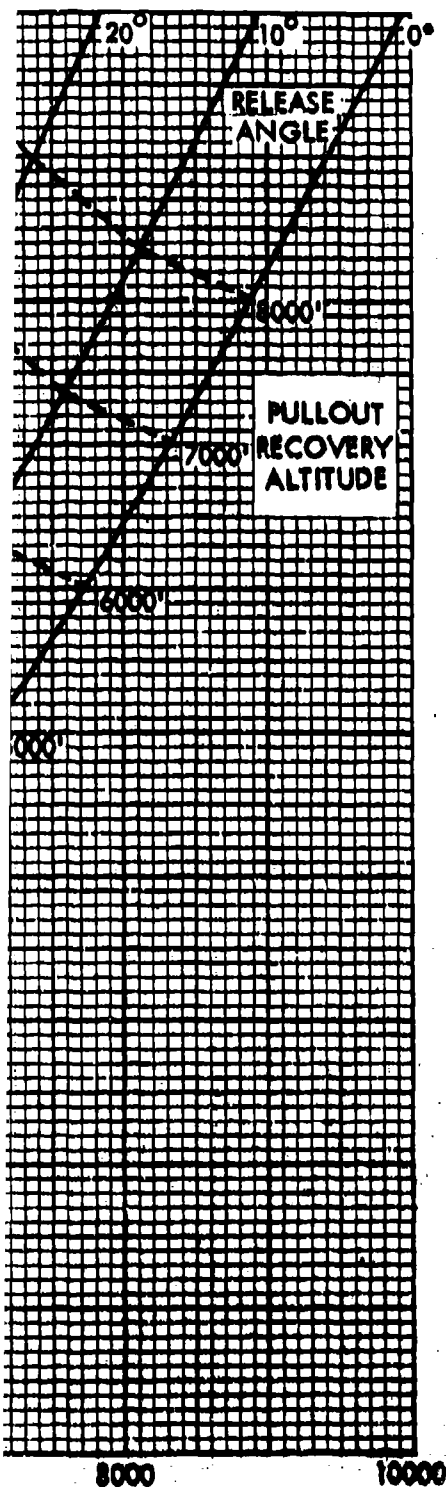
—— BOMB RELEASE CURVE
---- AIRPLANE PULLOUT CURVE
—— CONSTANT TIME OF FALL CURVE
---- 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY
2.0 g PULLOUT

FIG. 91 MK 82/UNRETARDED EJ VEL 10 FPS



NOLTR 65-230

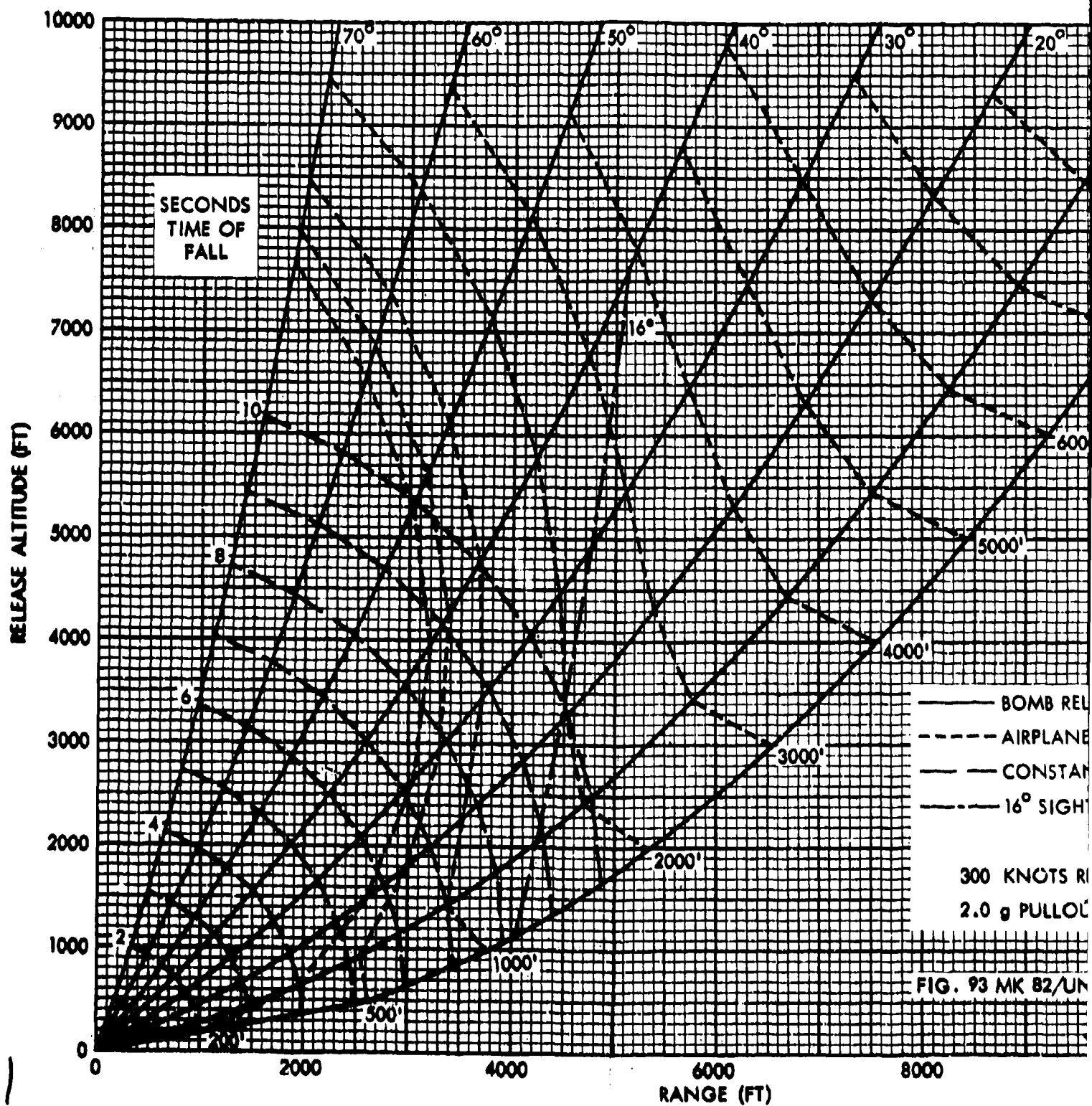


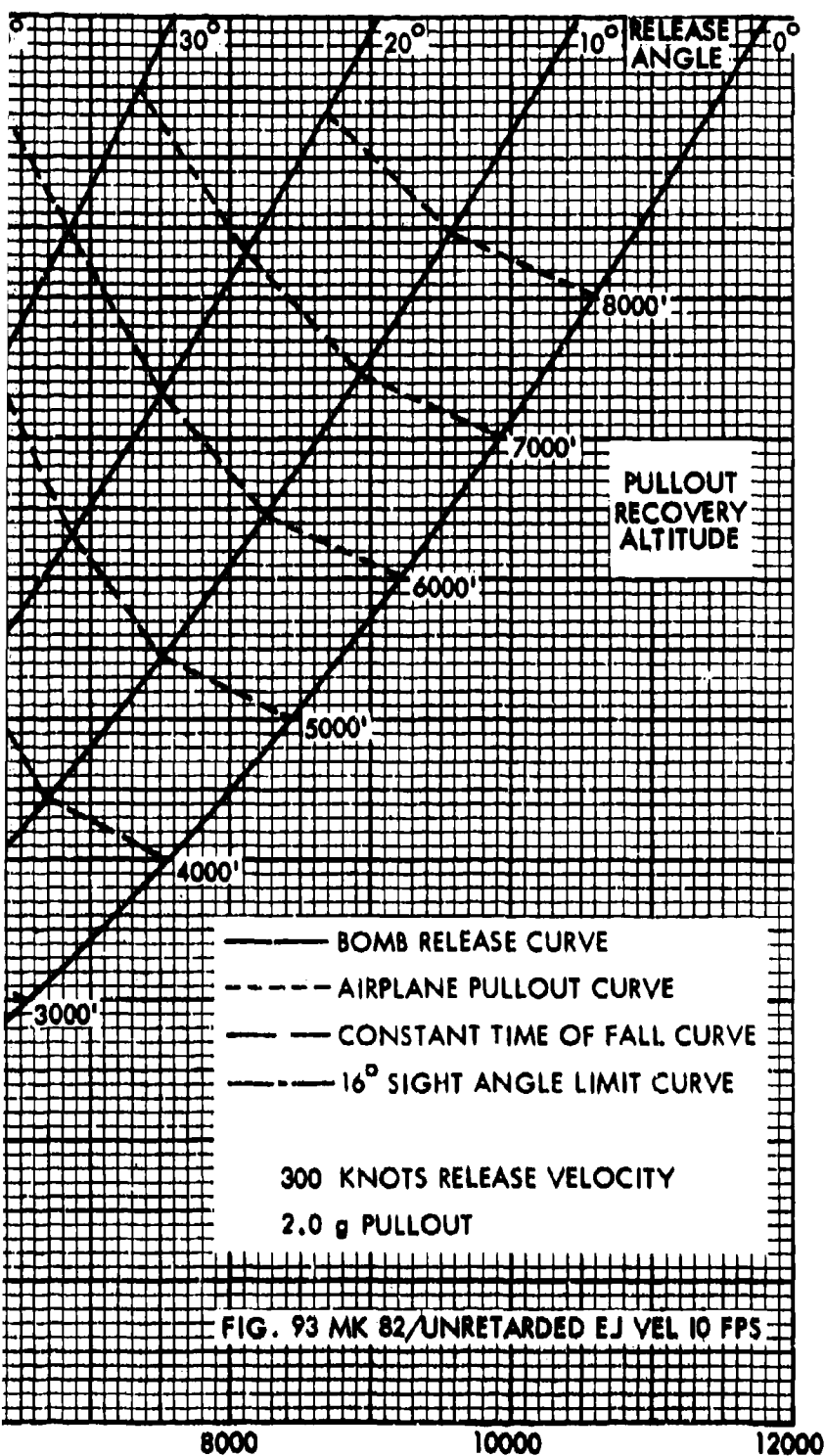
- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

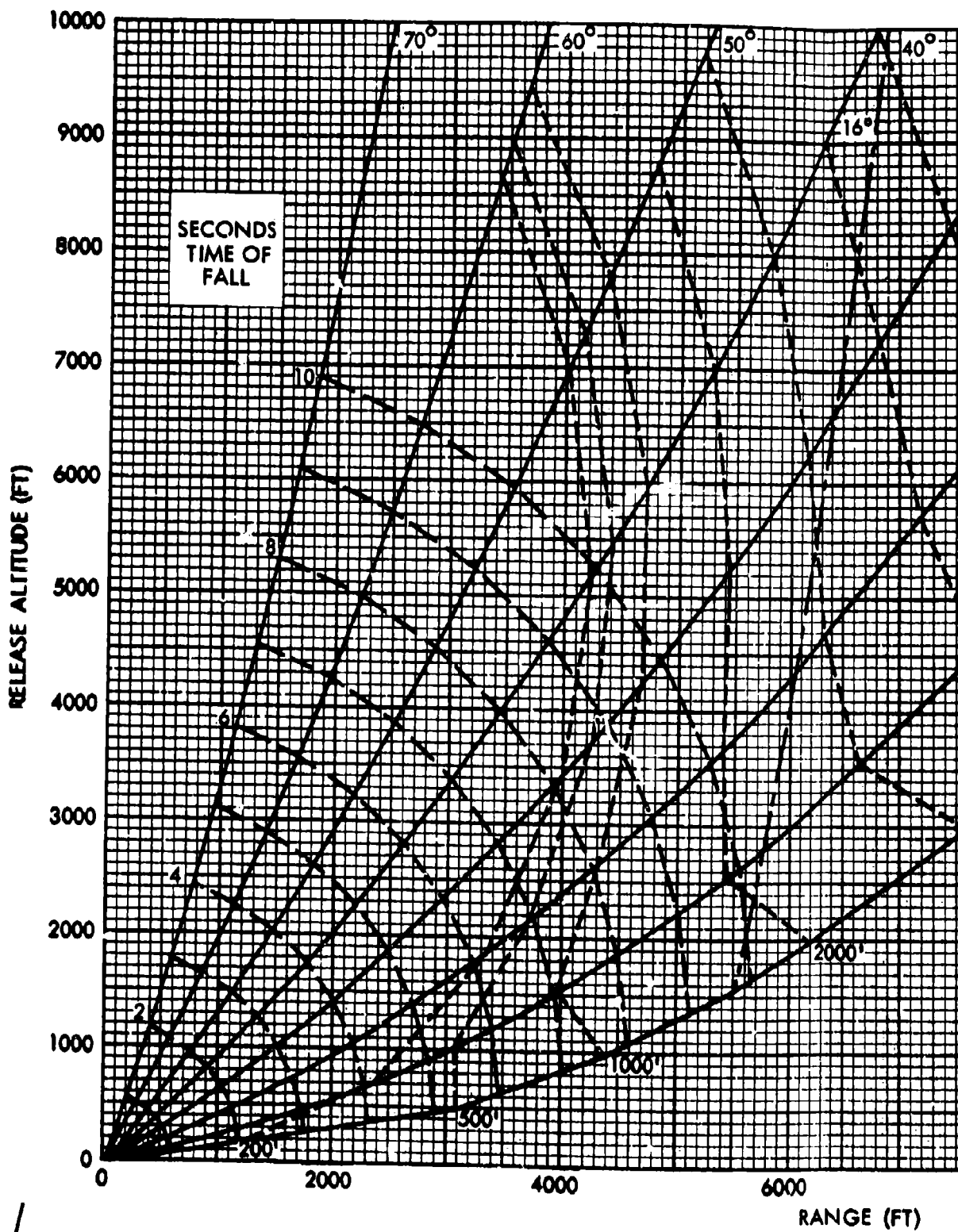
250 KNOTS RELEASE VELOCITY

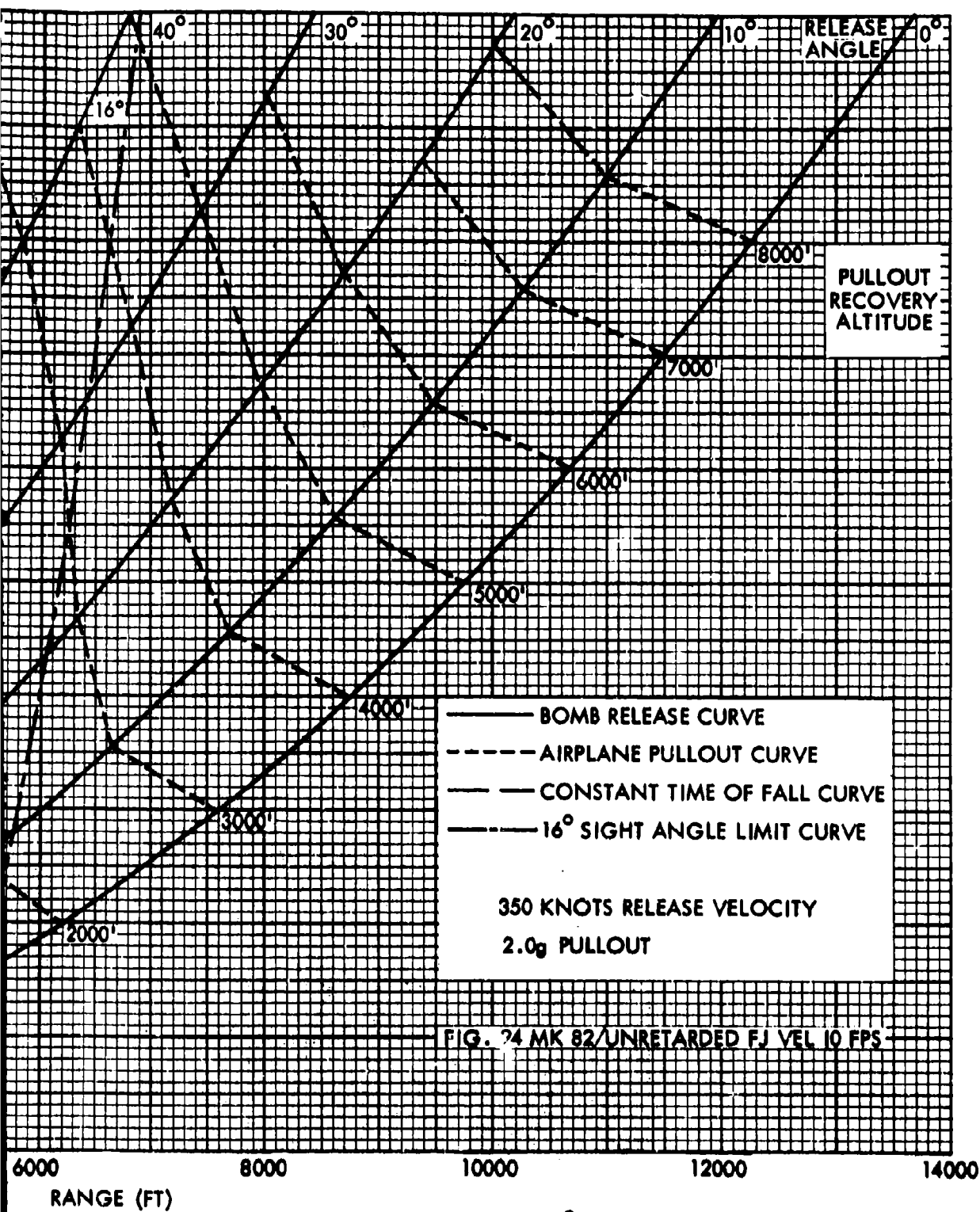
2.0 g PULLOUT

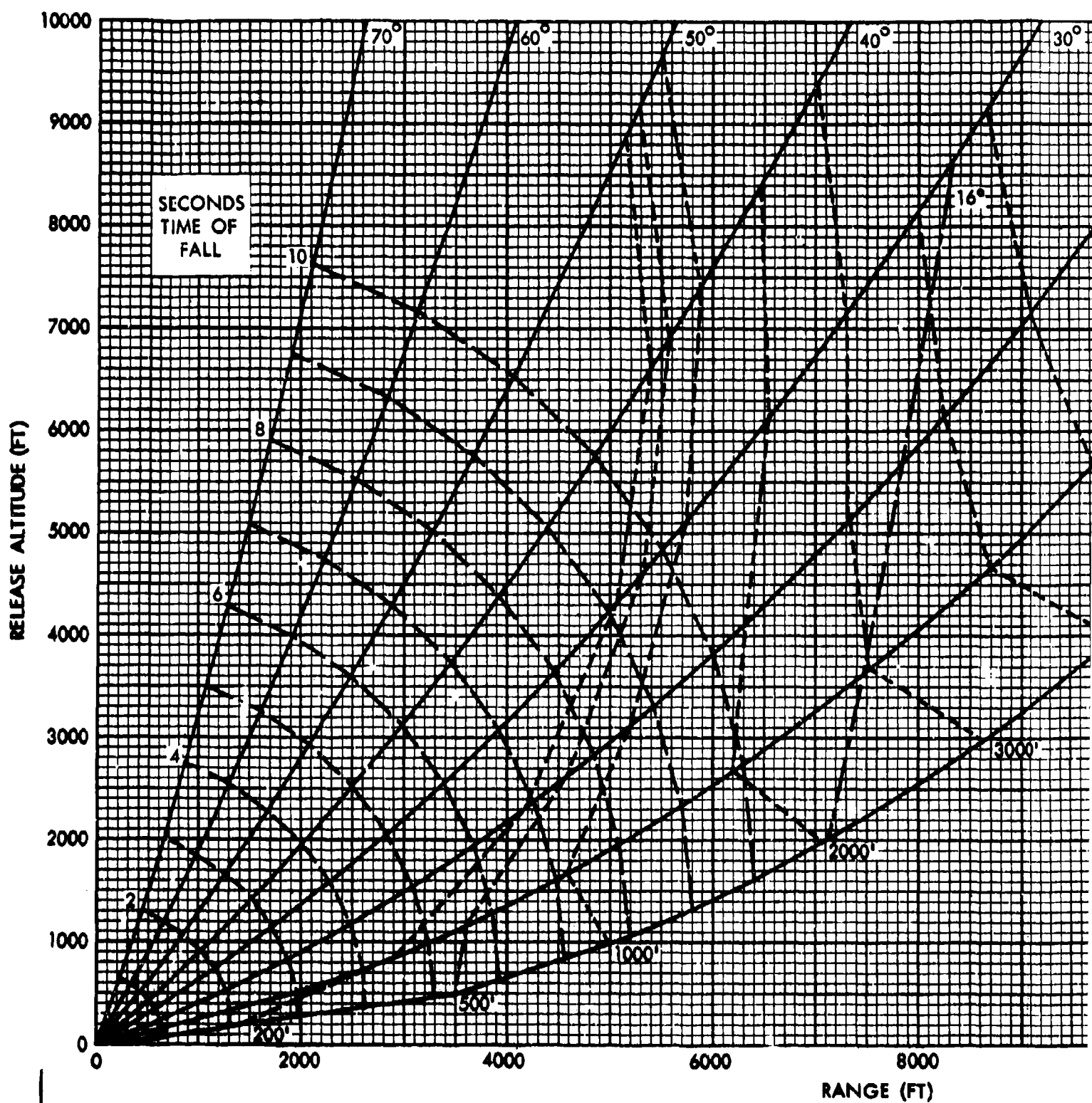
FIG. 92 MK 82/UNRETARDED EJ VEL 10 FPS

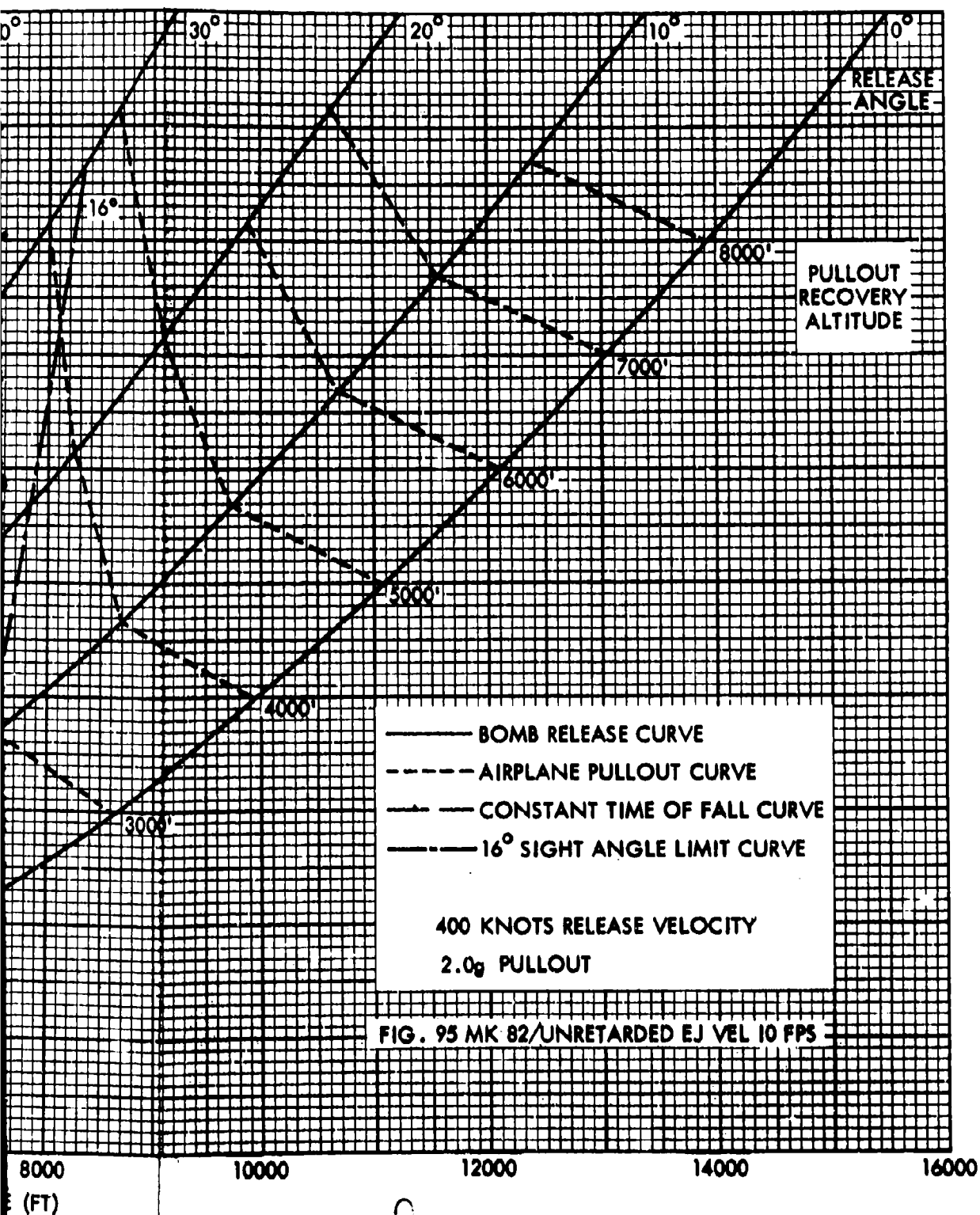




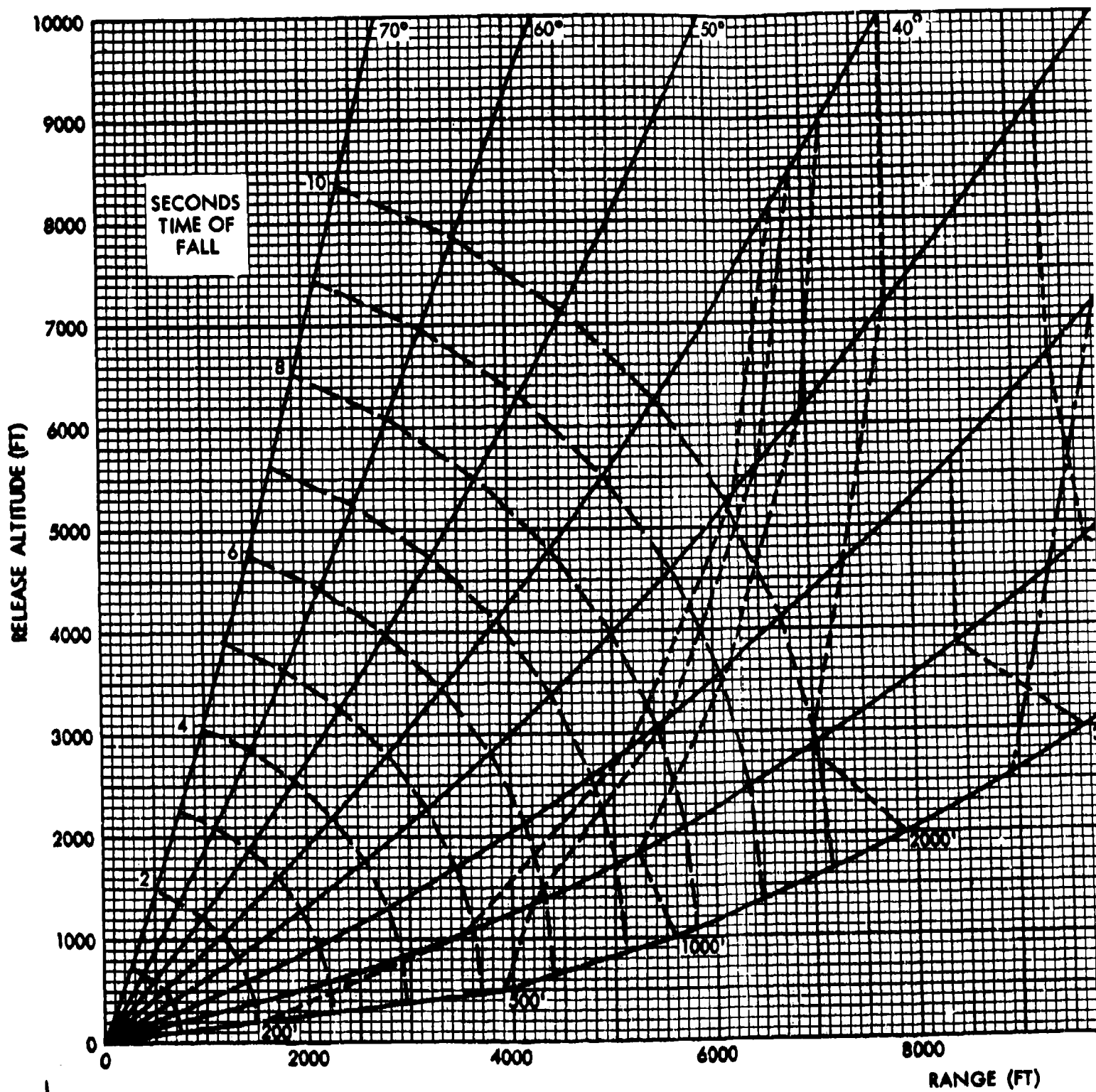


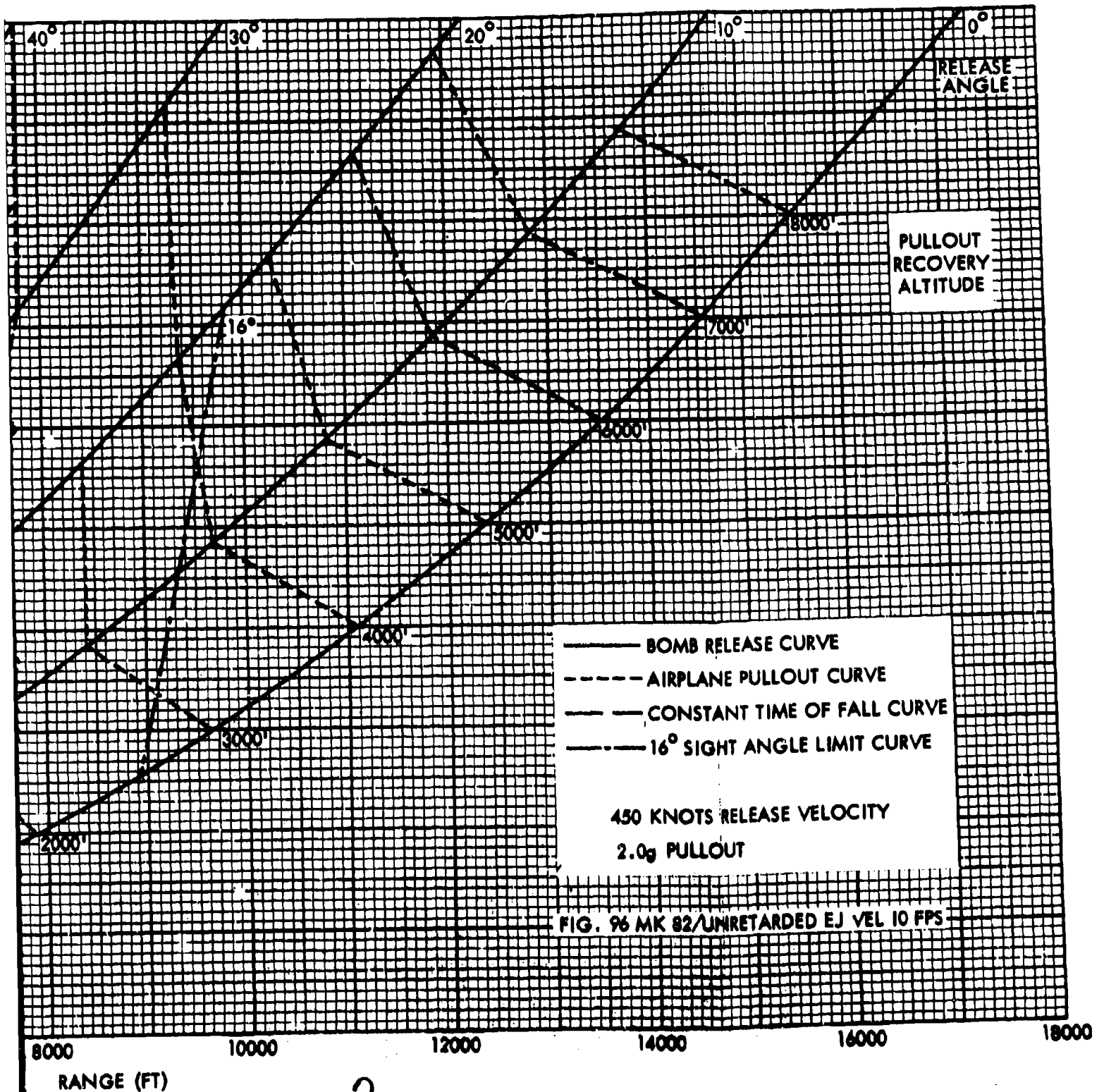


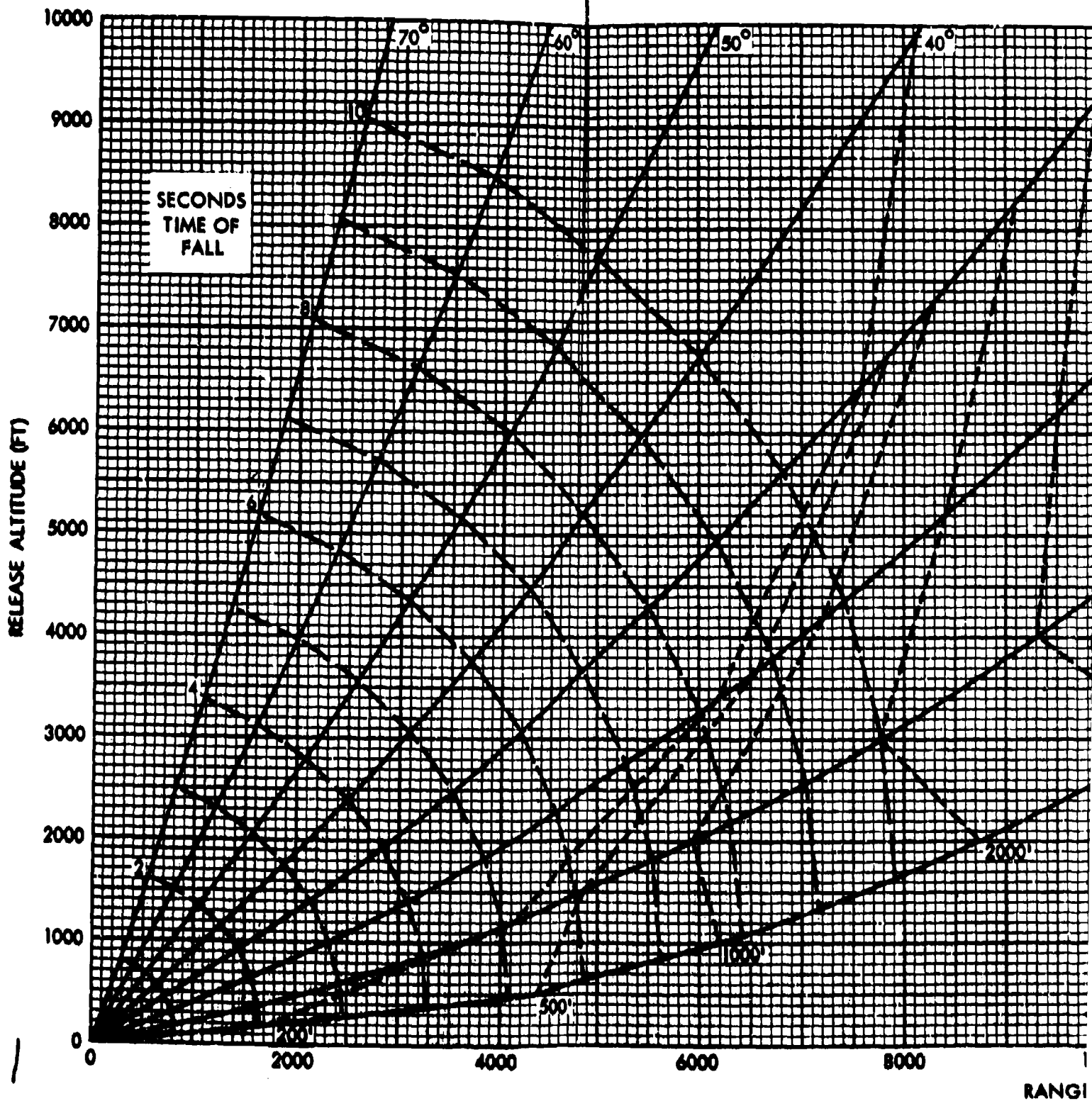


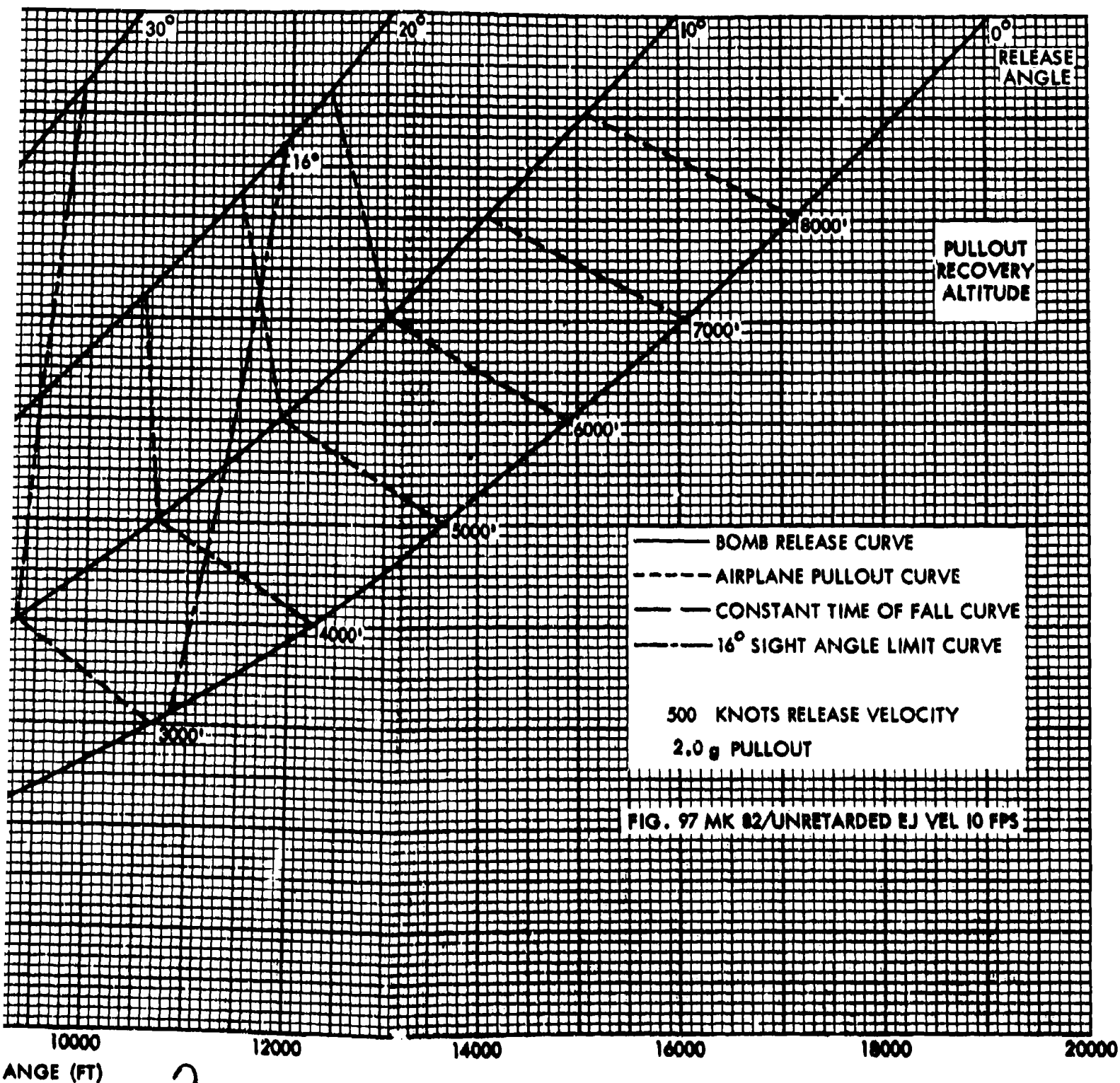


2

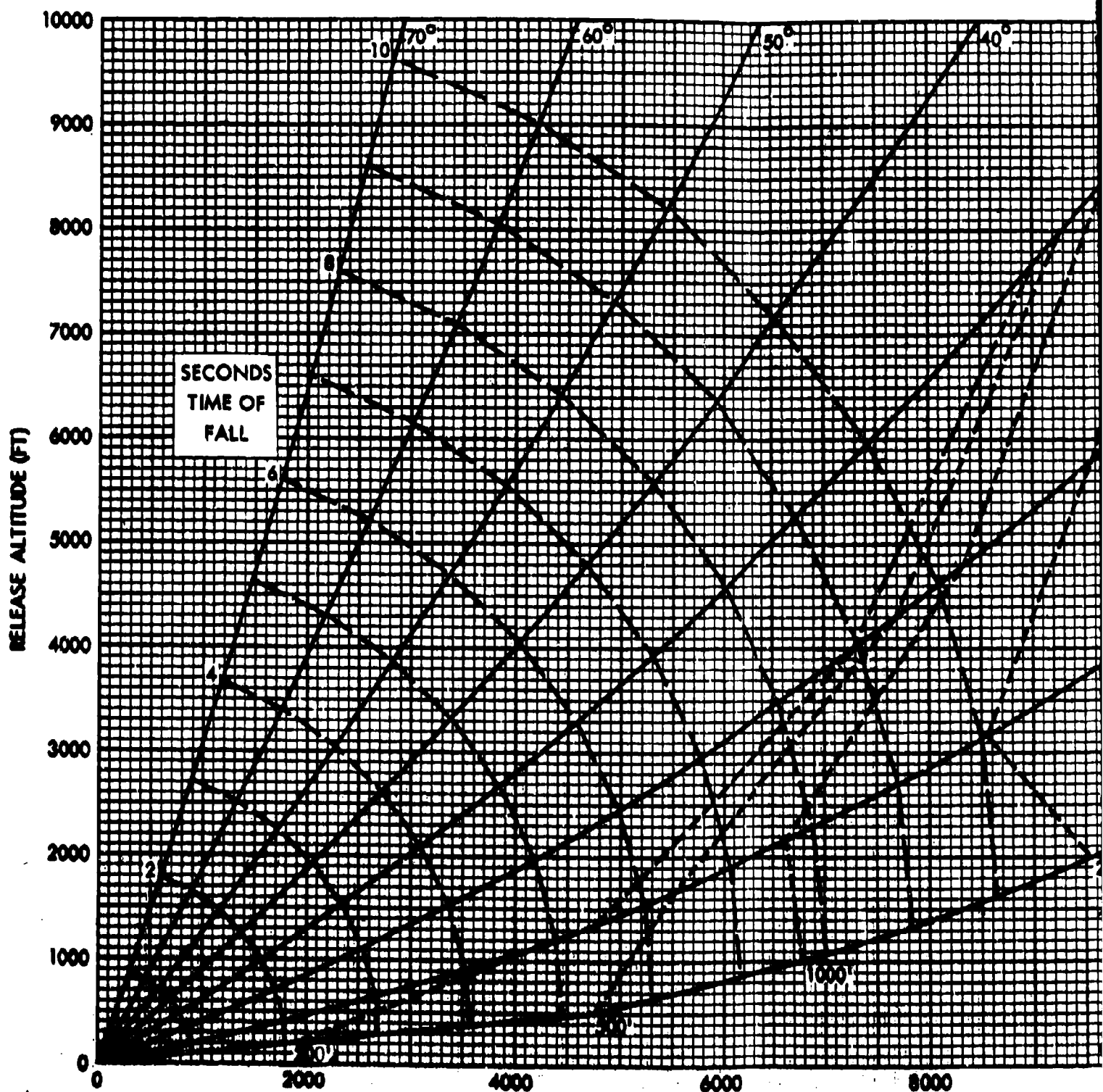








2



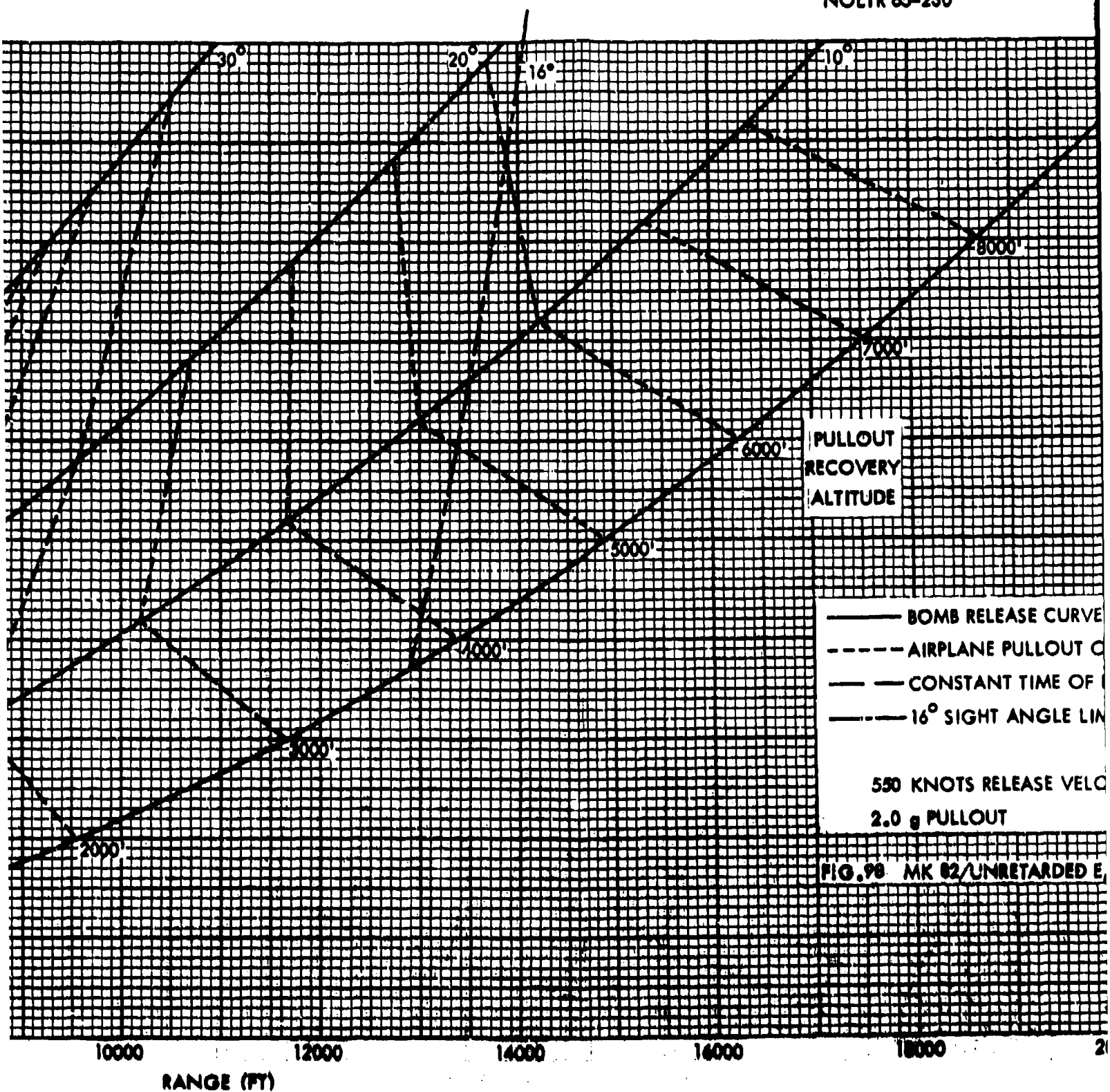
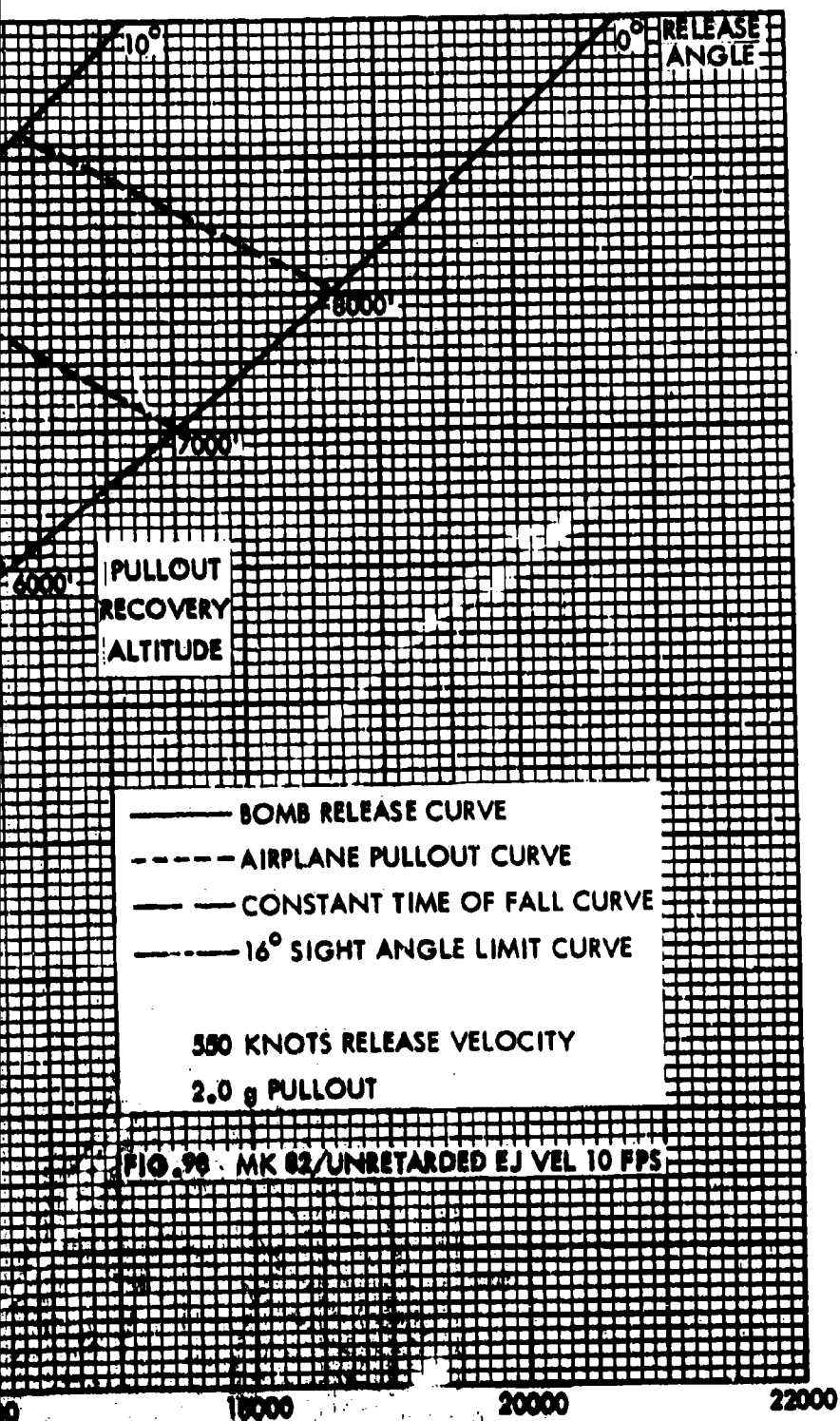
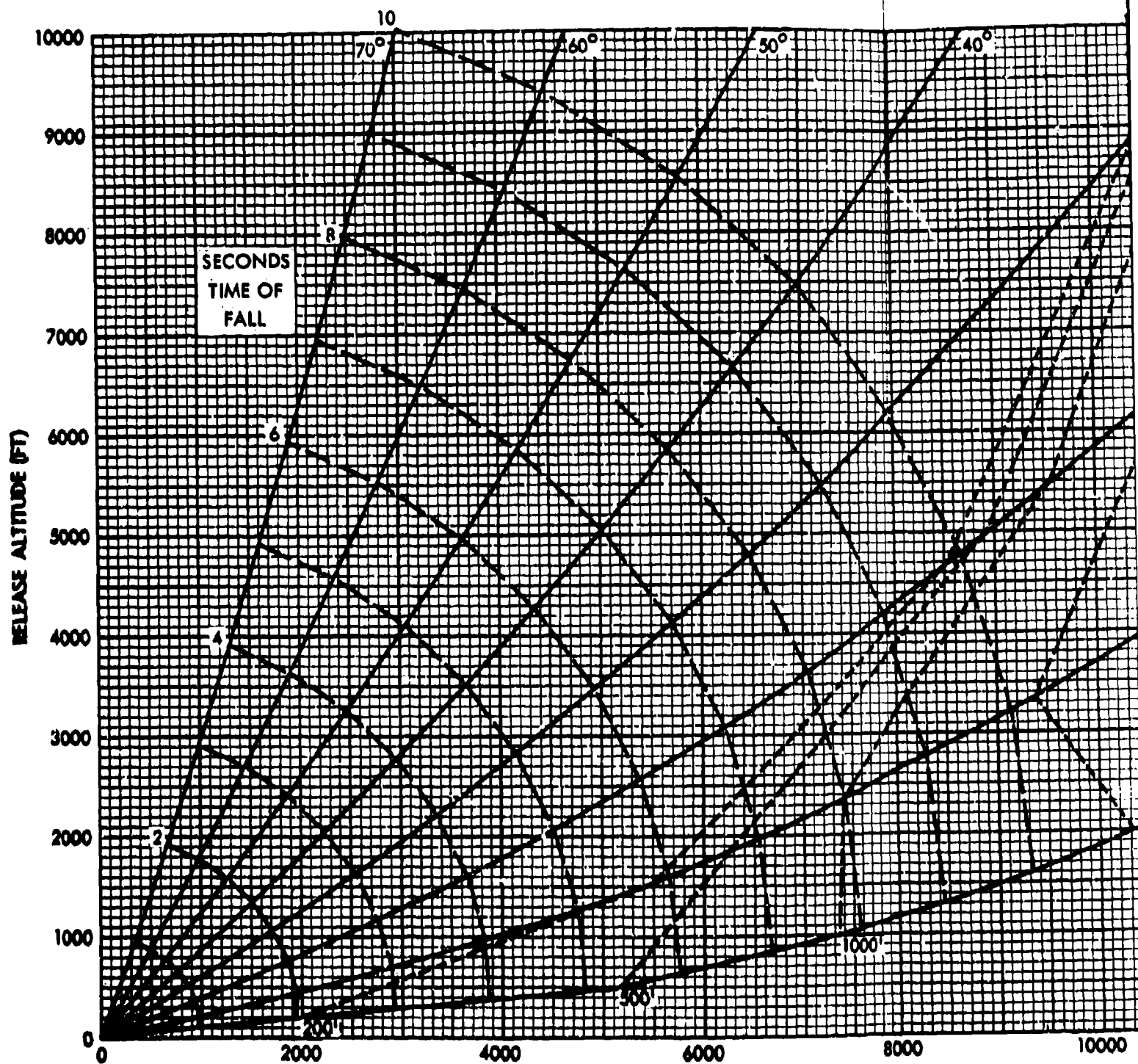
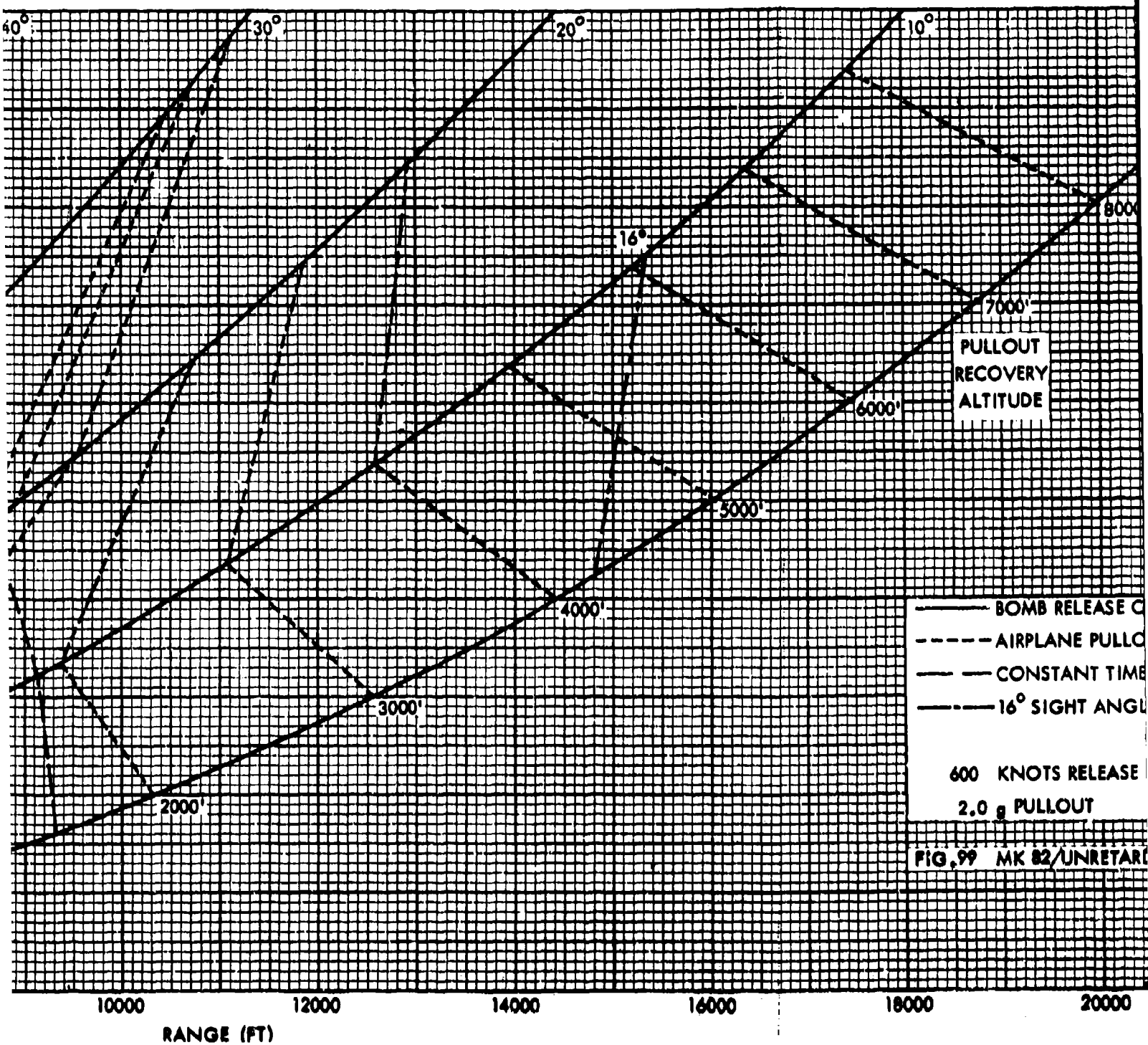


FIG. 98 MK 82/UNRETARDED E

NOLTR 65-230







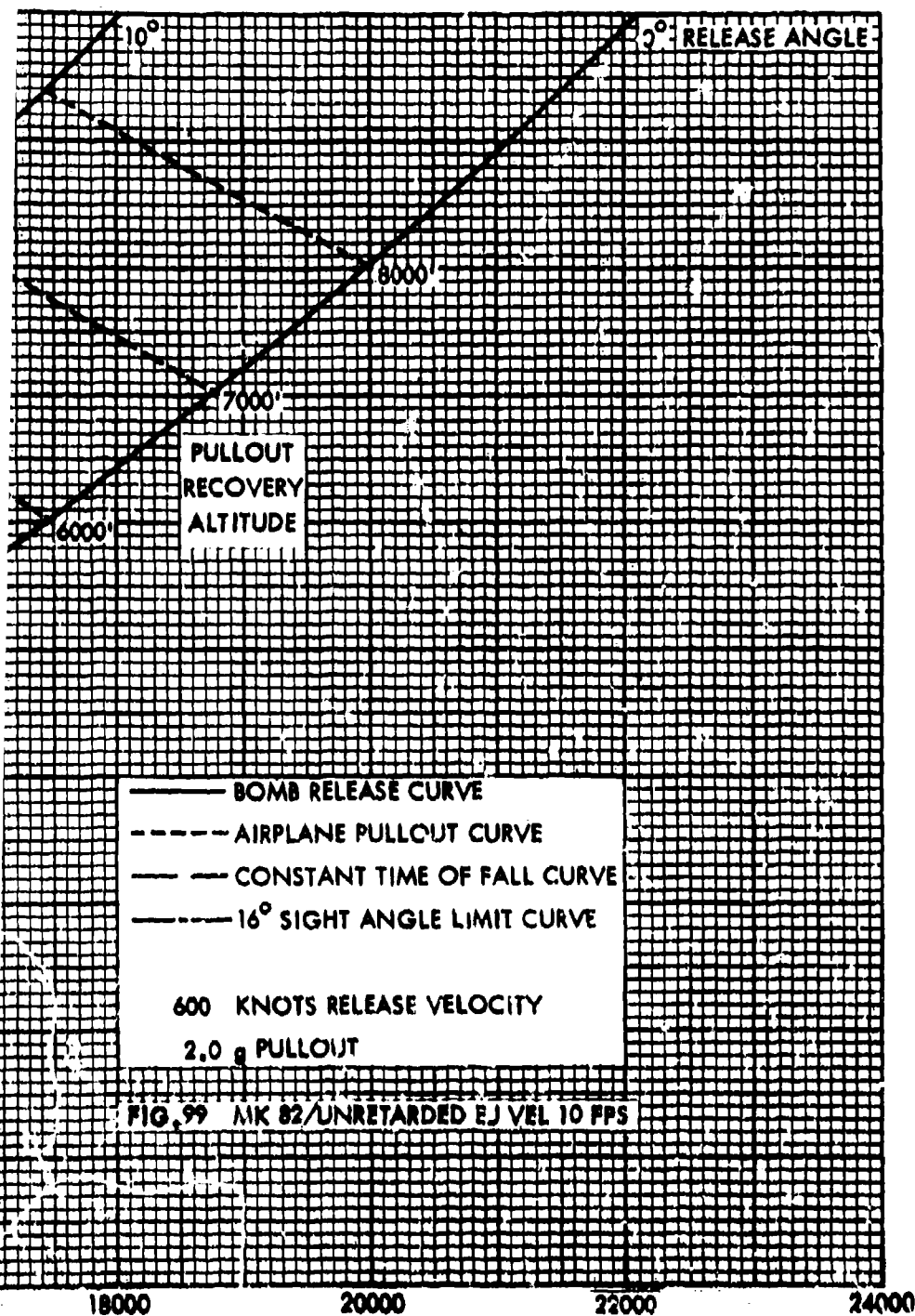
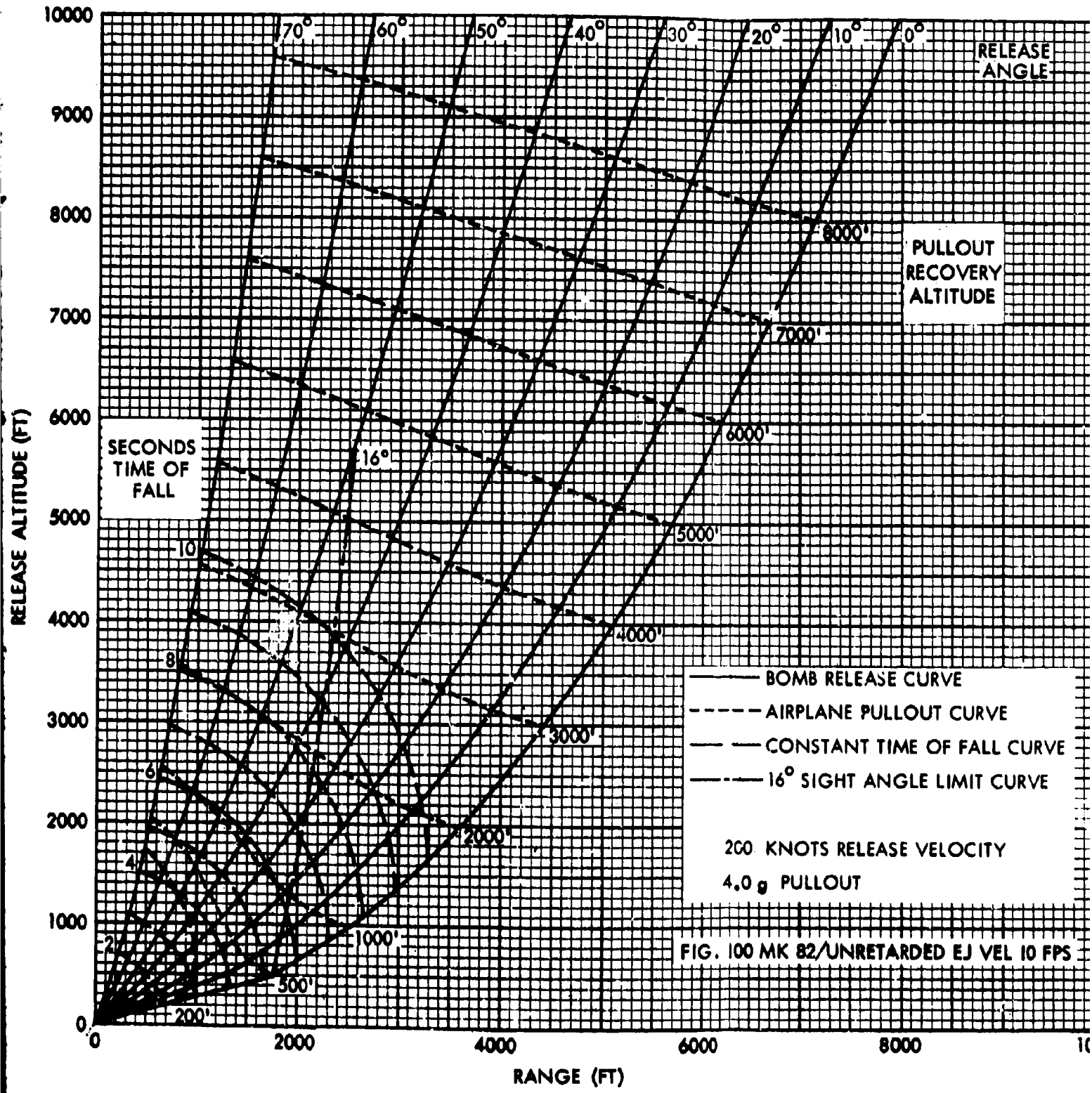
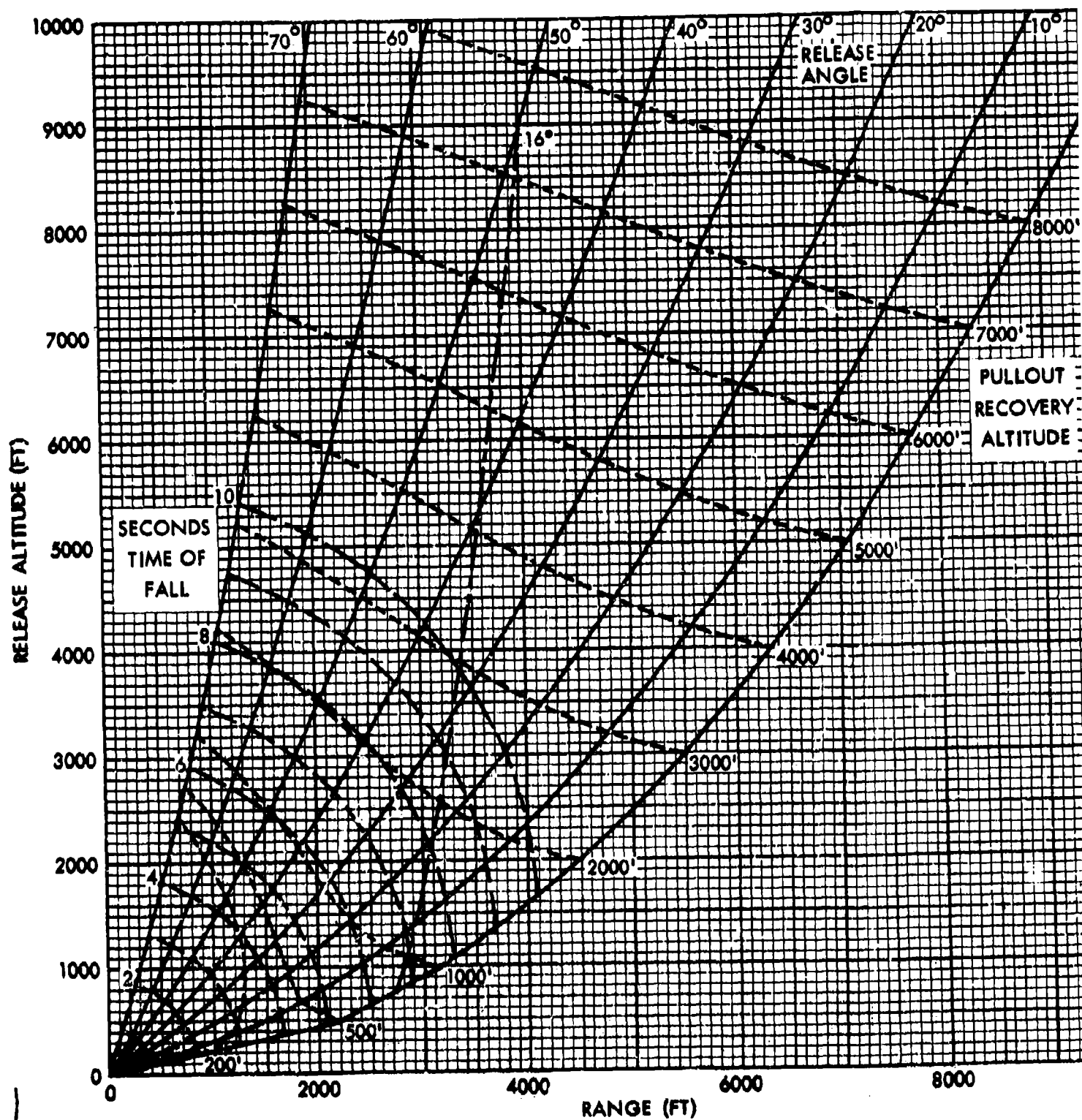
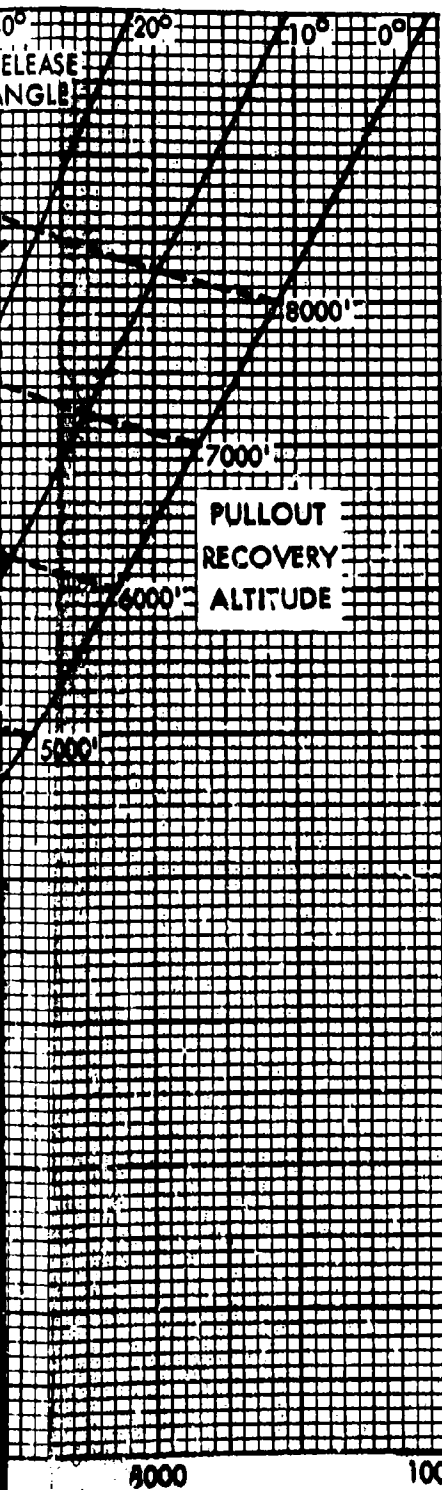


FIG. 99 MK 82/UNRETARDED EJ VEL 10 FPS





NOLTR 65-230



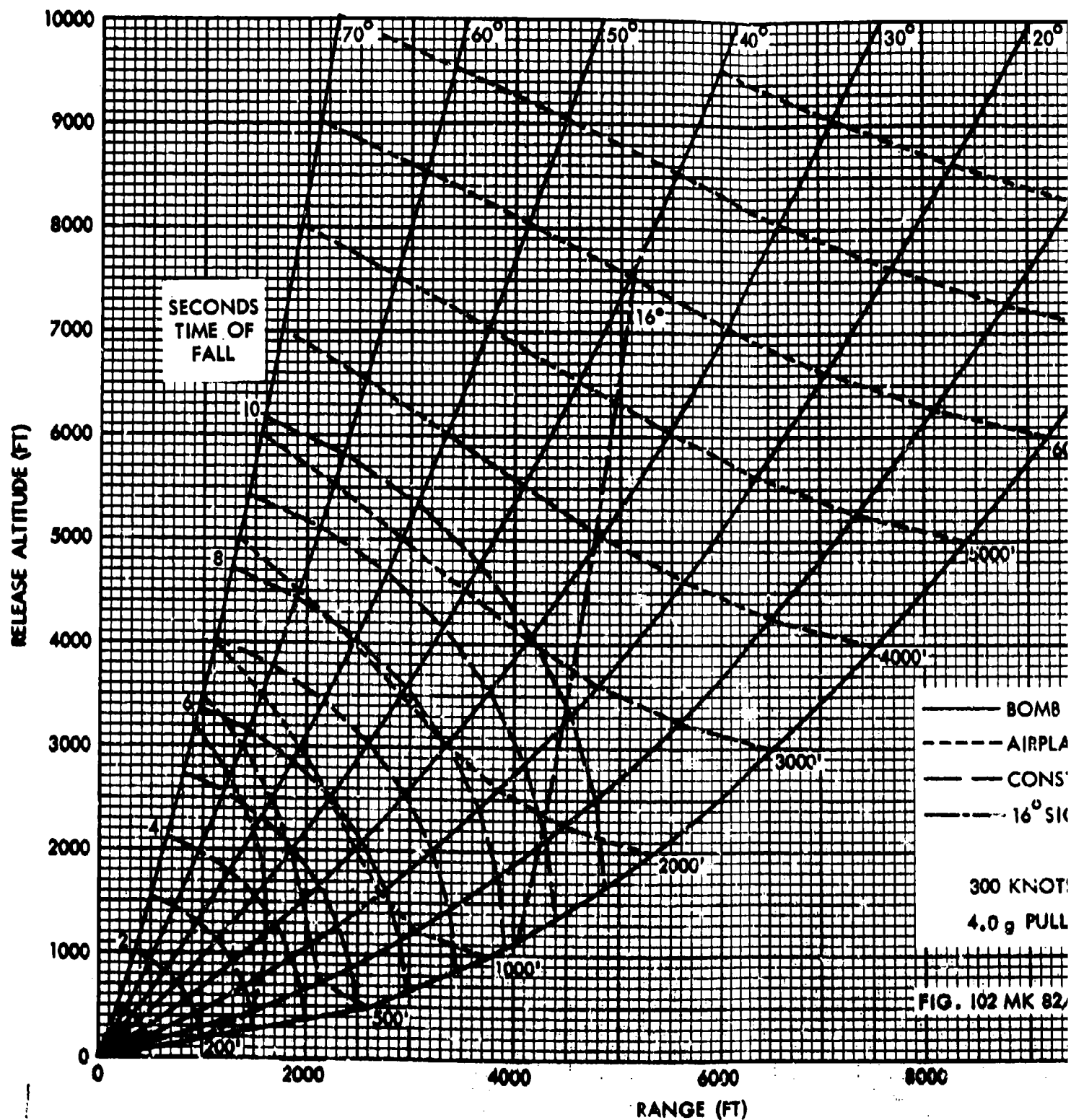
- BOMB RELEASE CURVE
- AIRPLANE PULLOUT CURVE
- CONSTANT TIME OF FALL CURVE
- 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

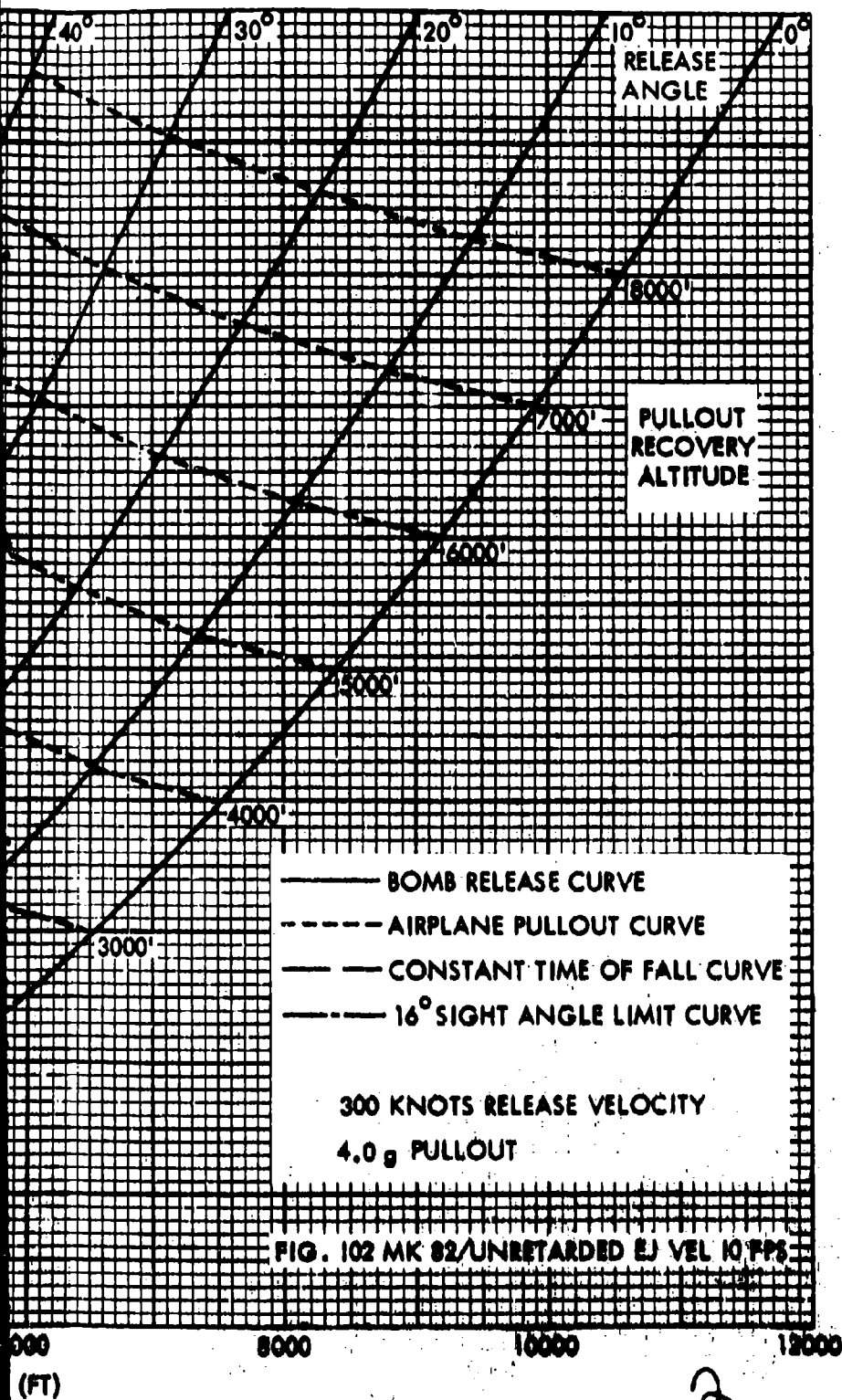
4.0 g PULLOUT

FIG. 101 MK 82/UNRETARDED EJ VEL 10 FPS

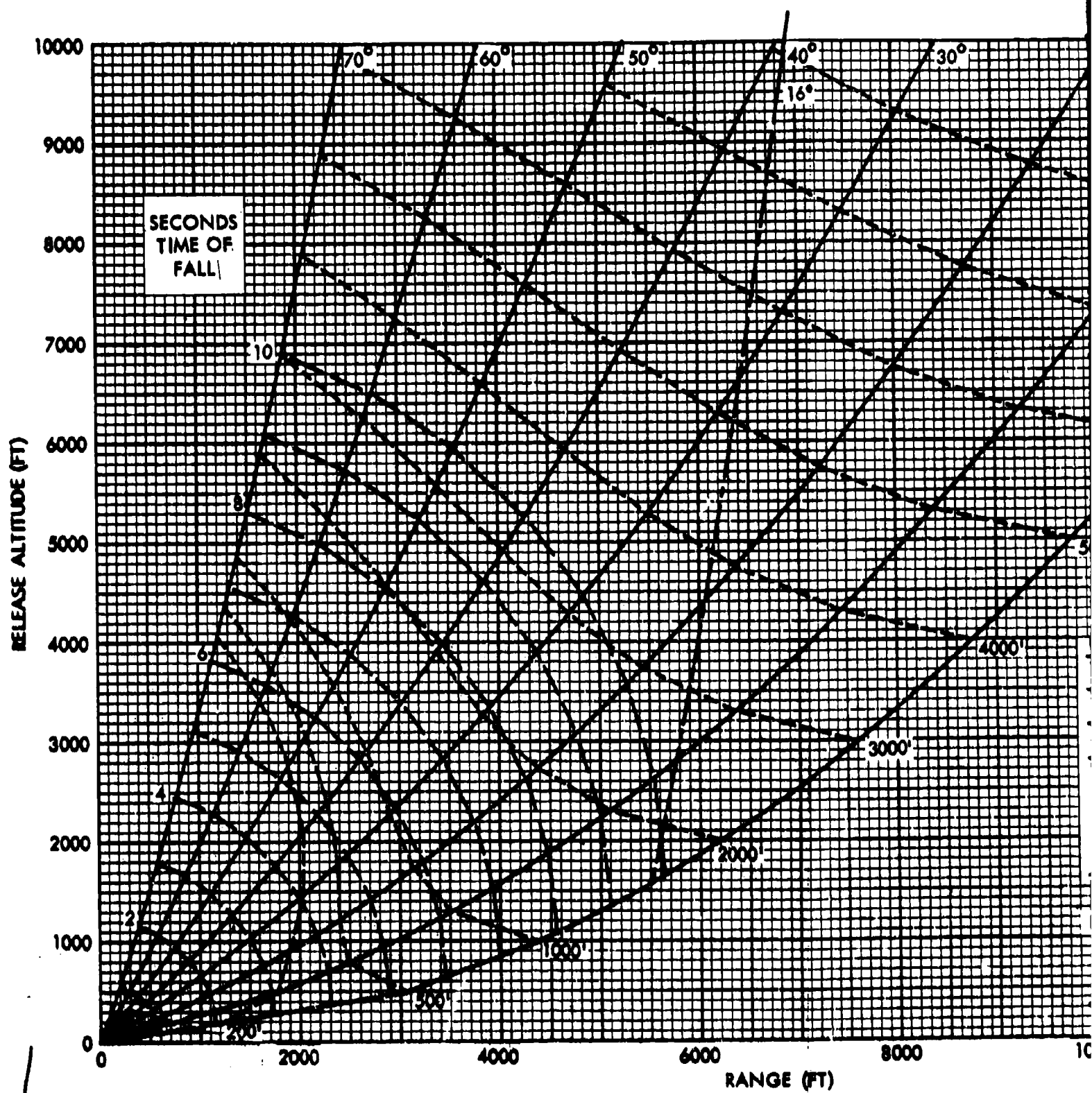
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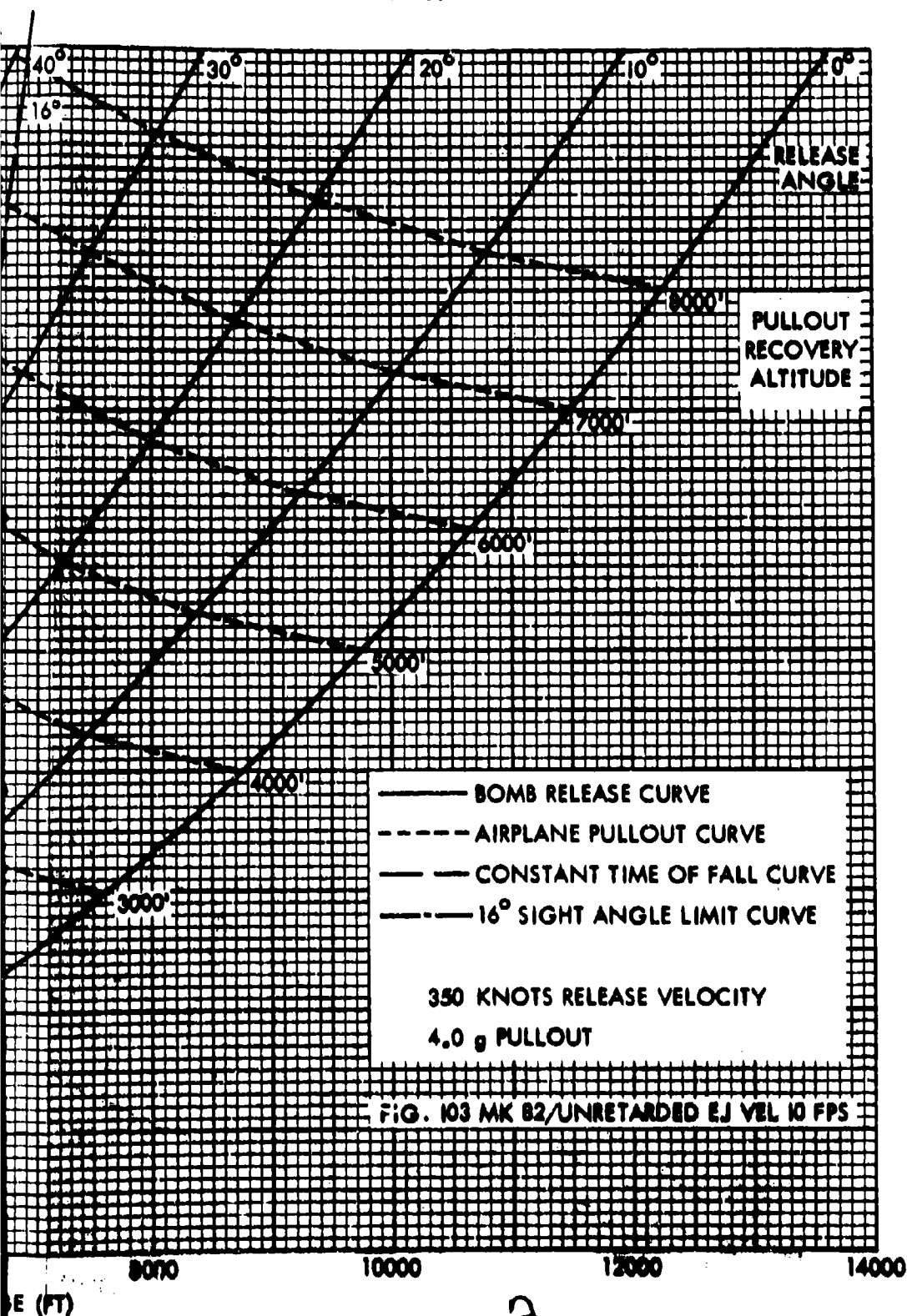
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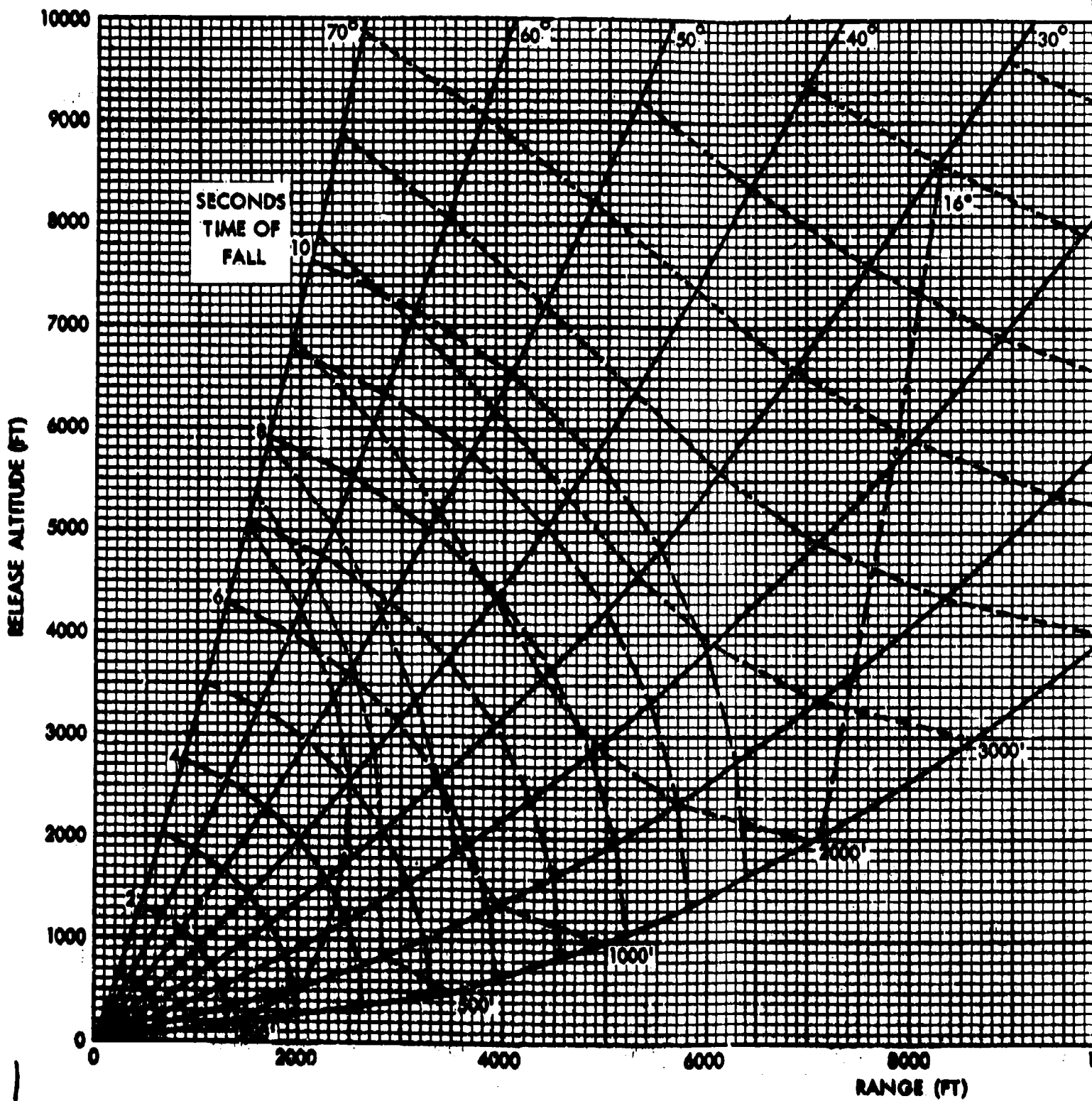
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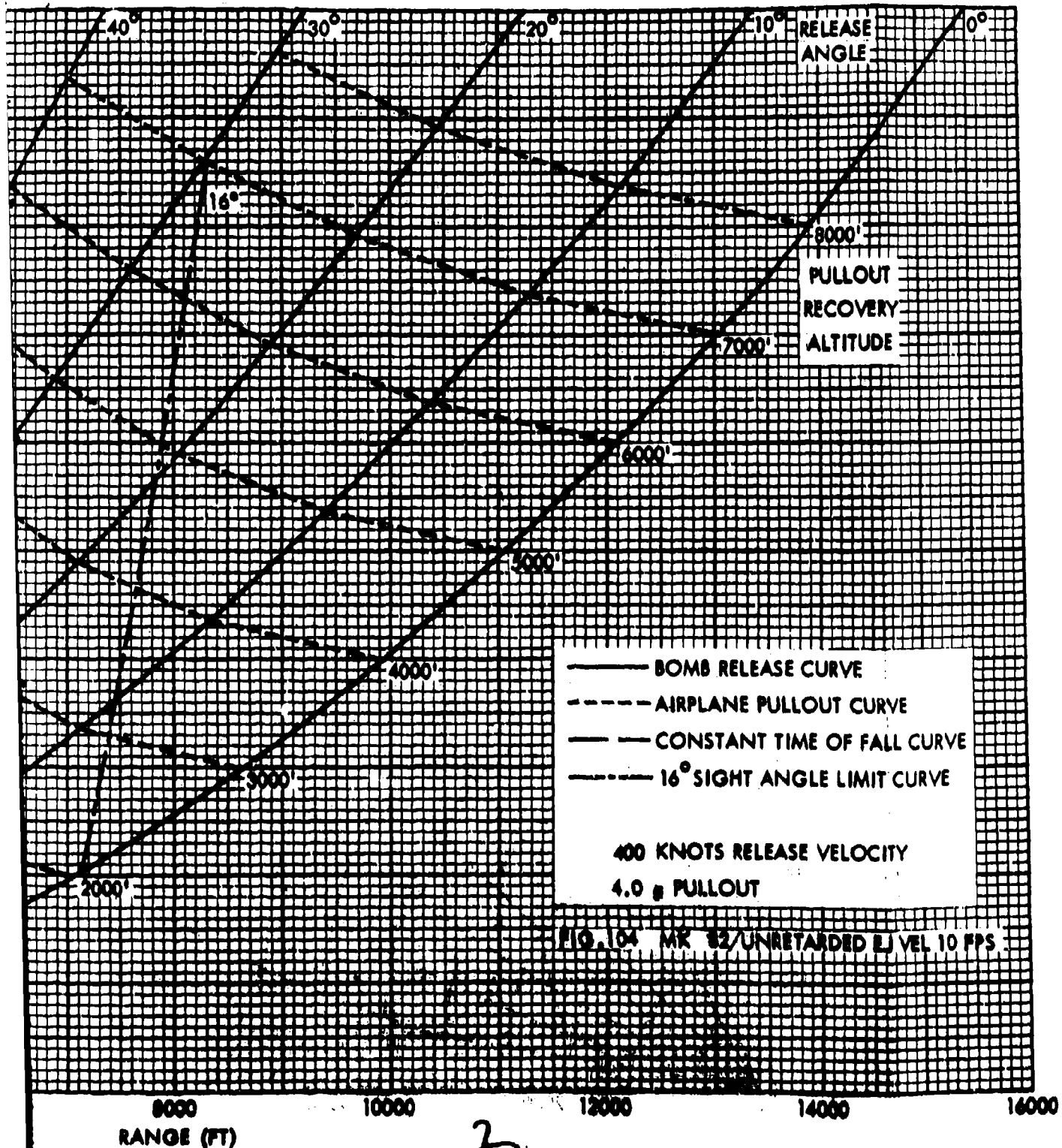


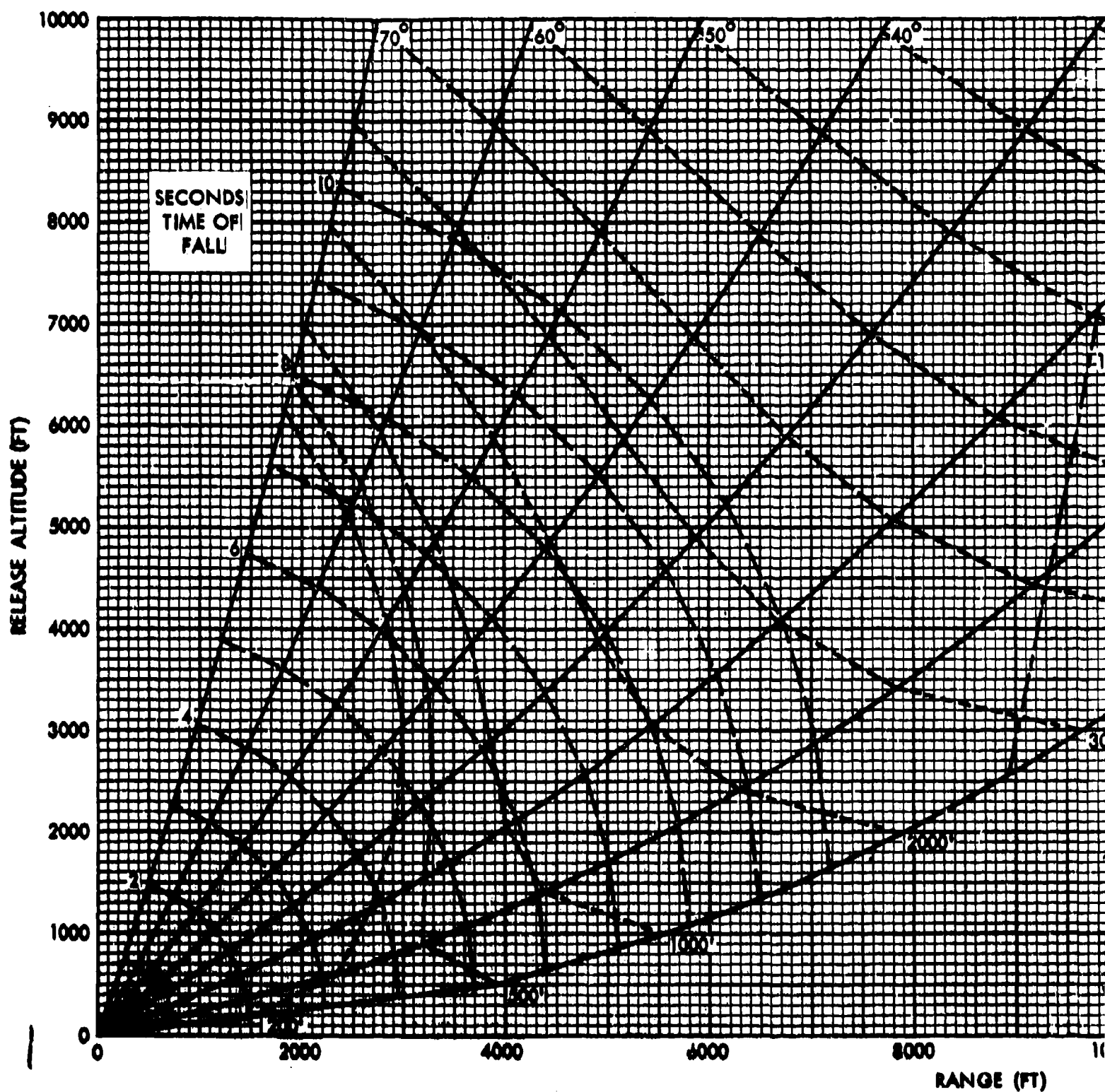
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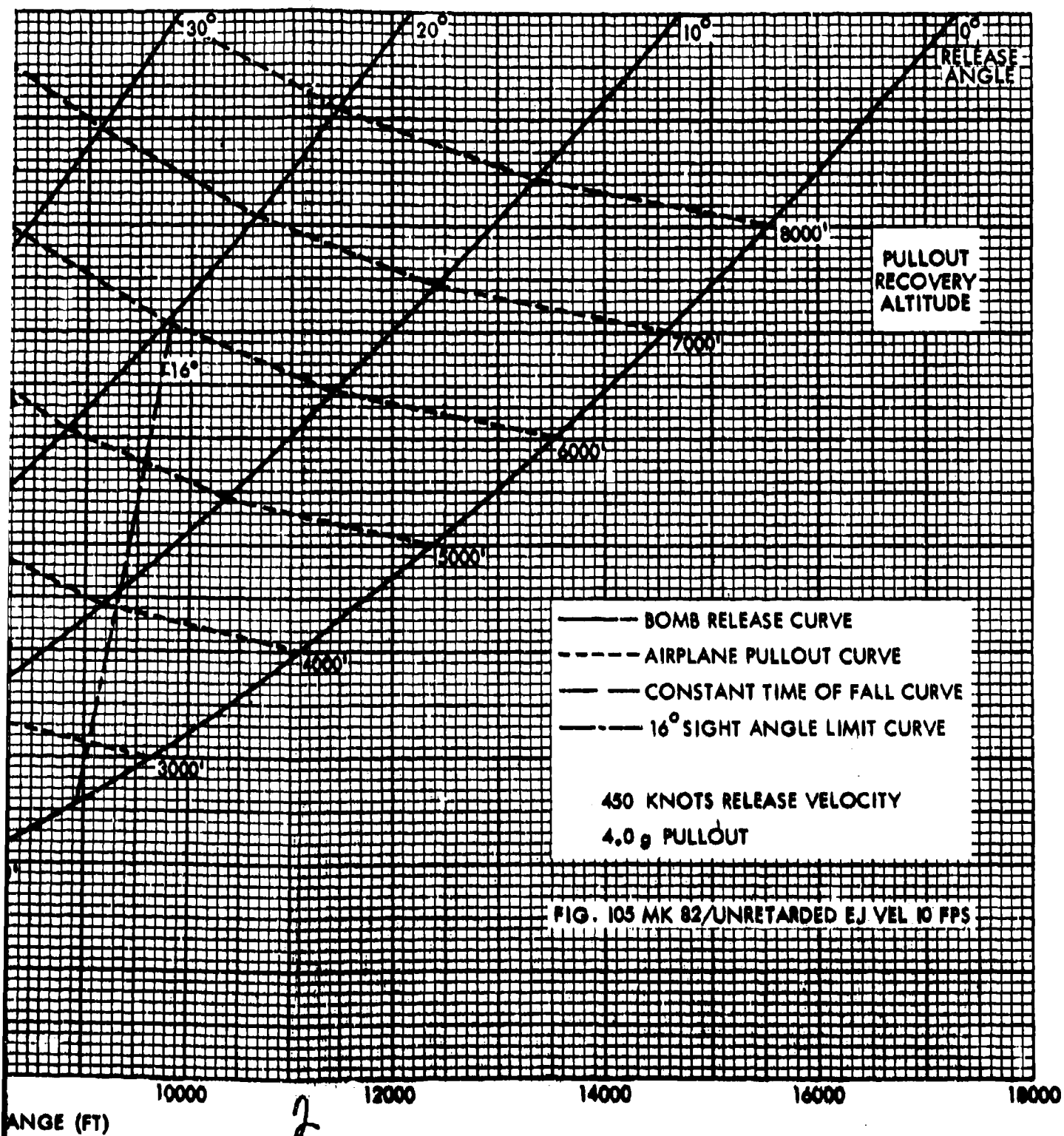


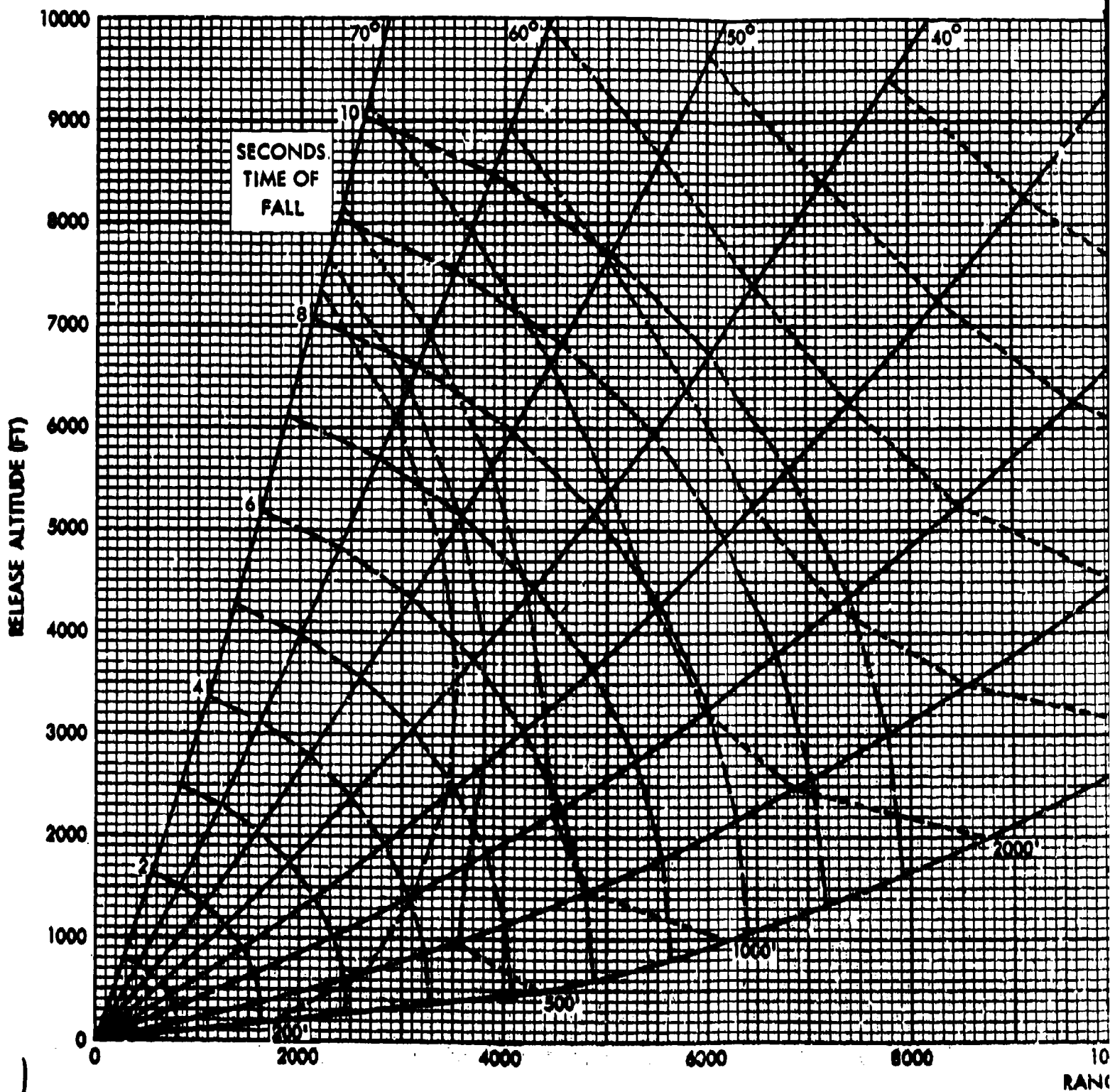
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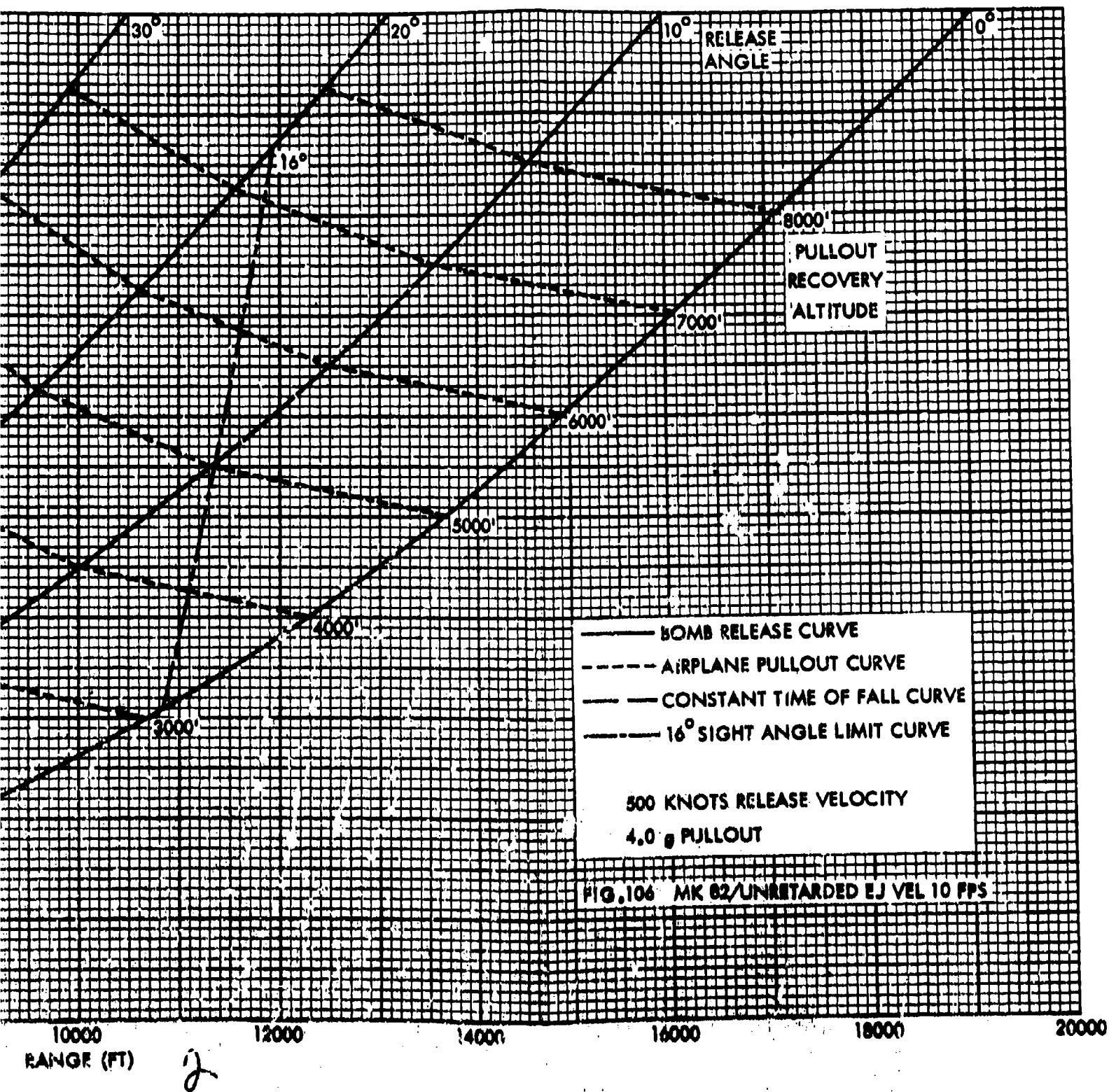


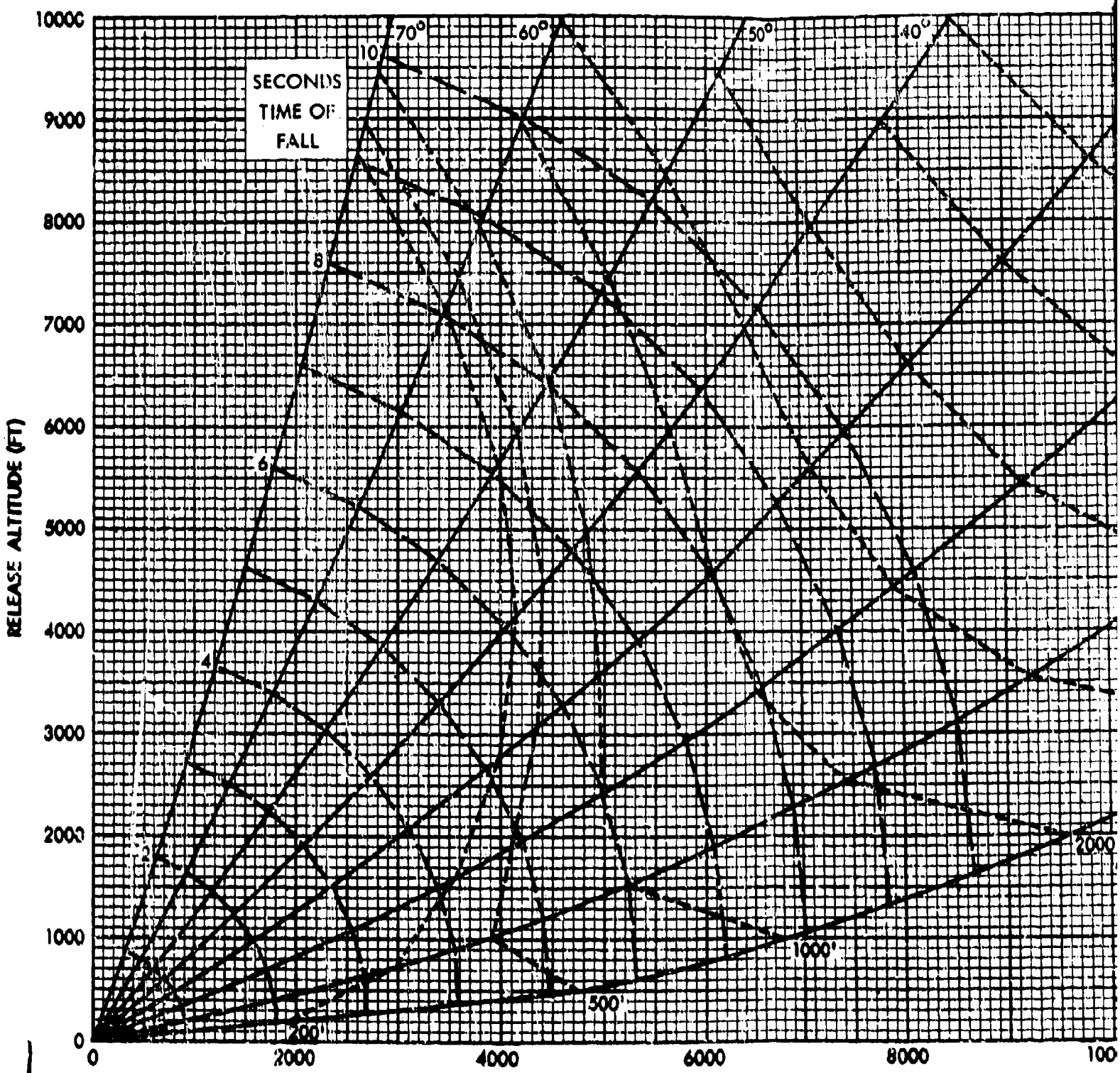


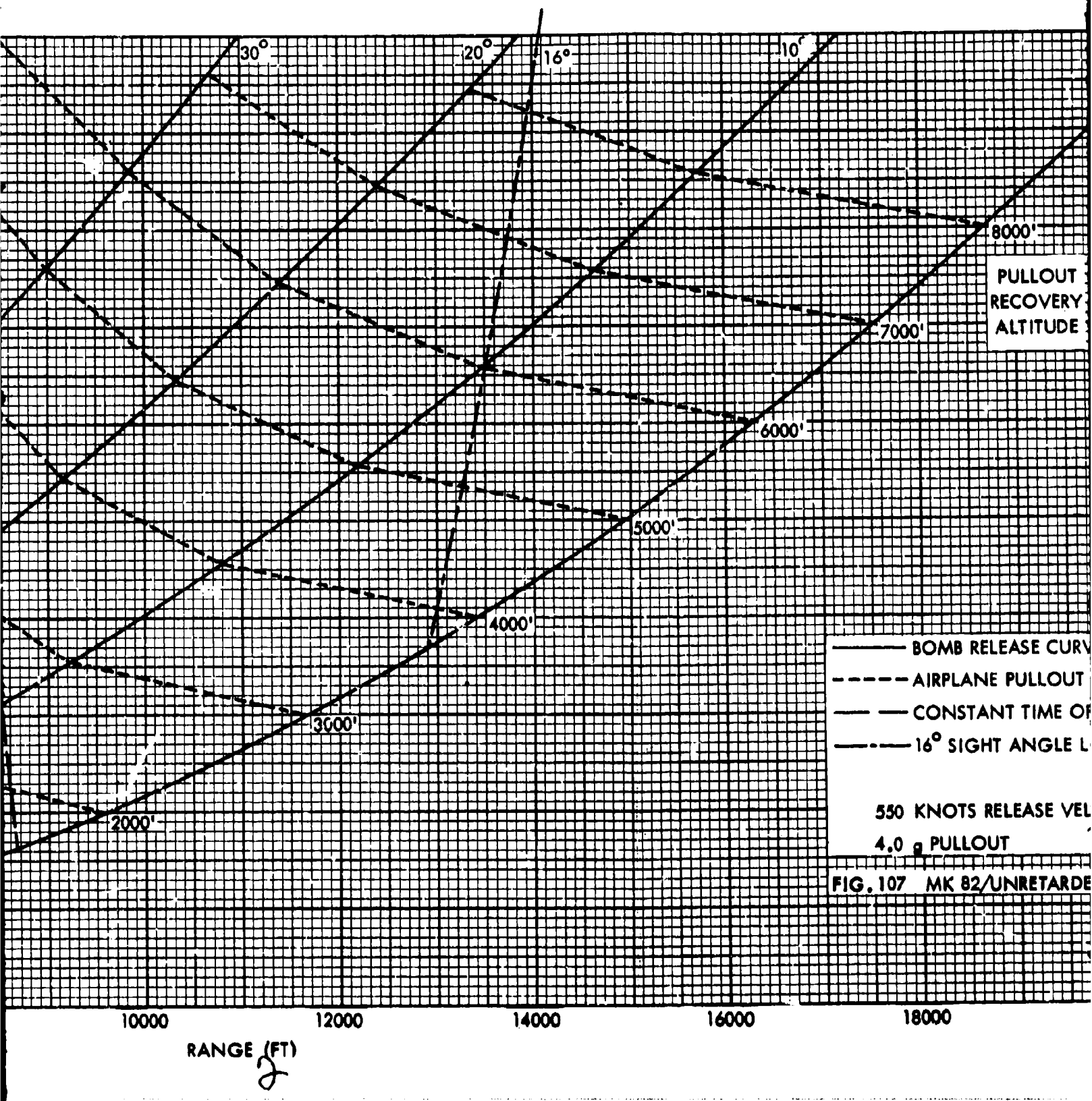












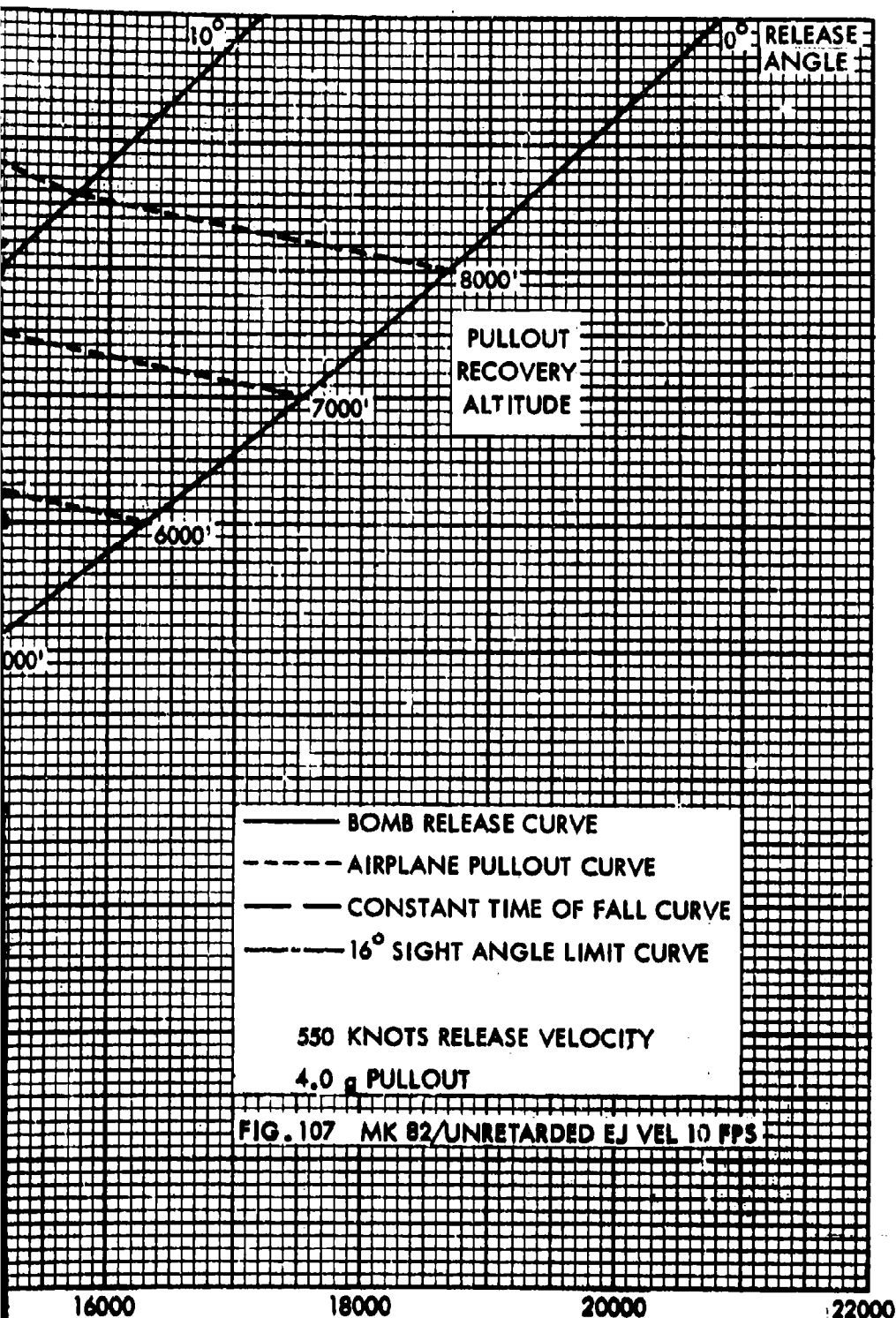
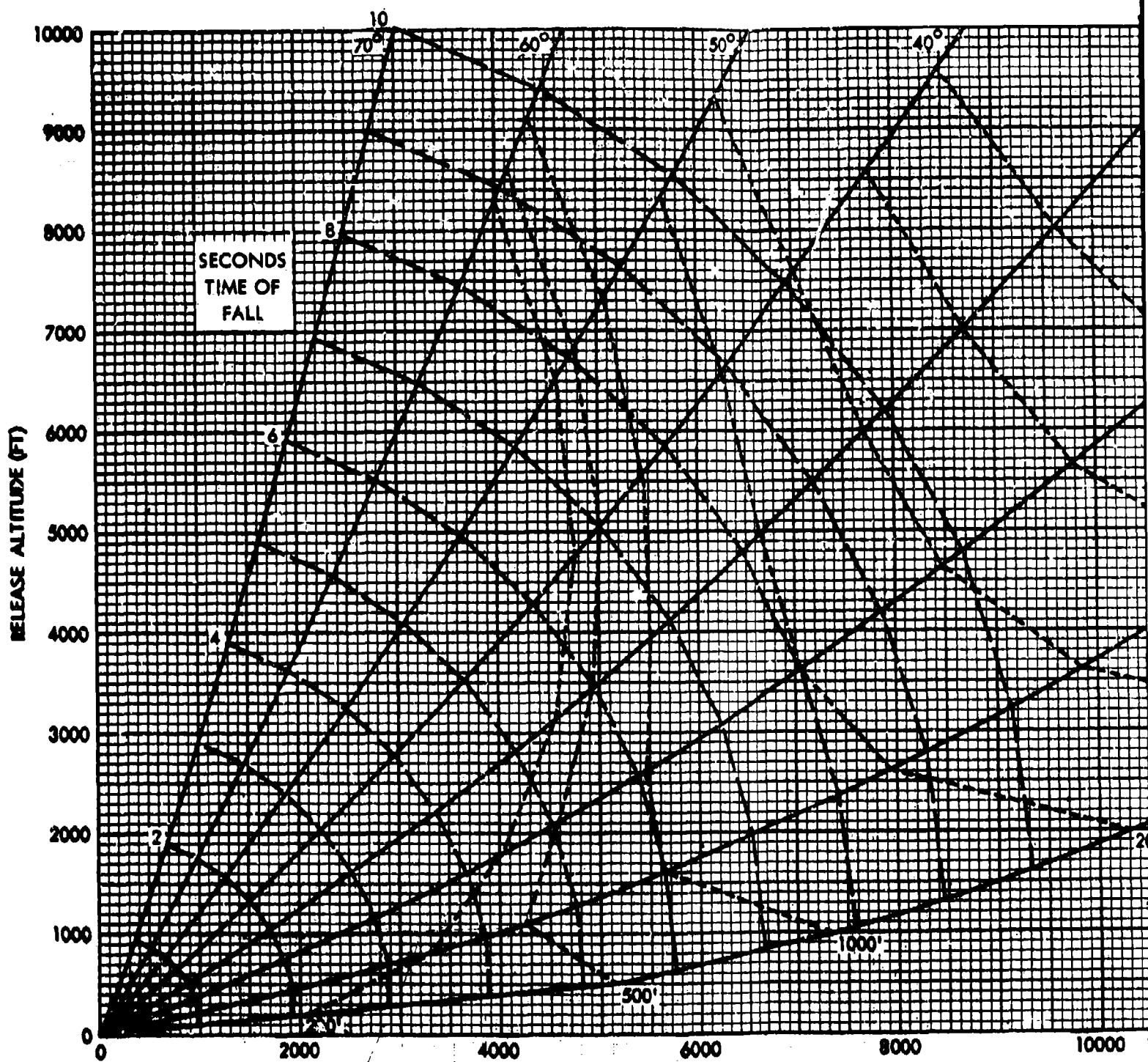


FIG. 107 MK 82/UNRETARDED EJ VEL 10 FPS



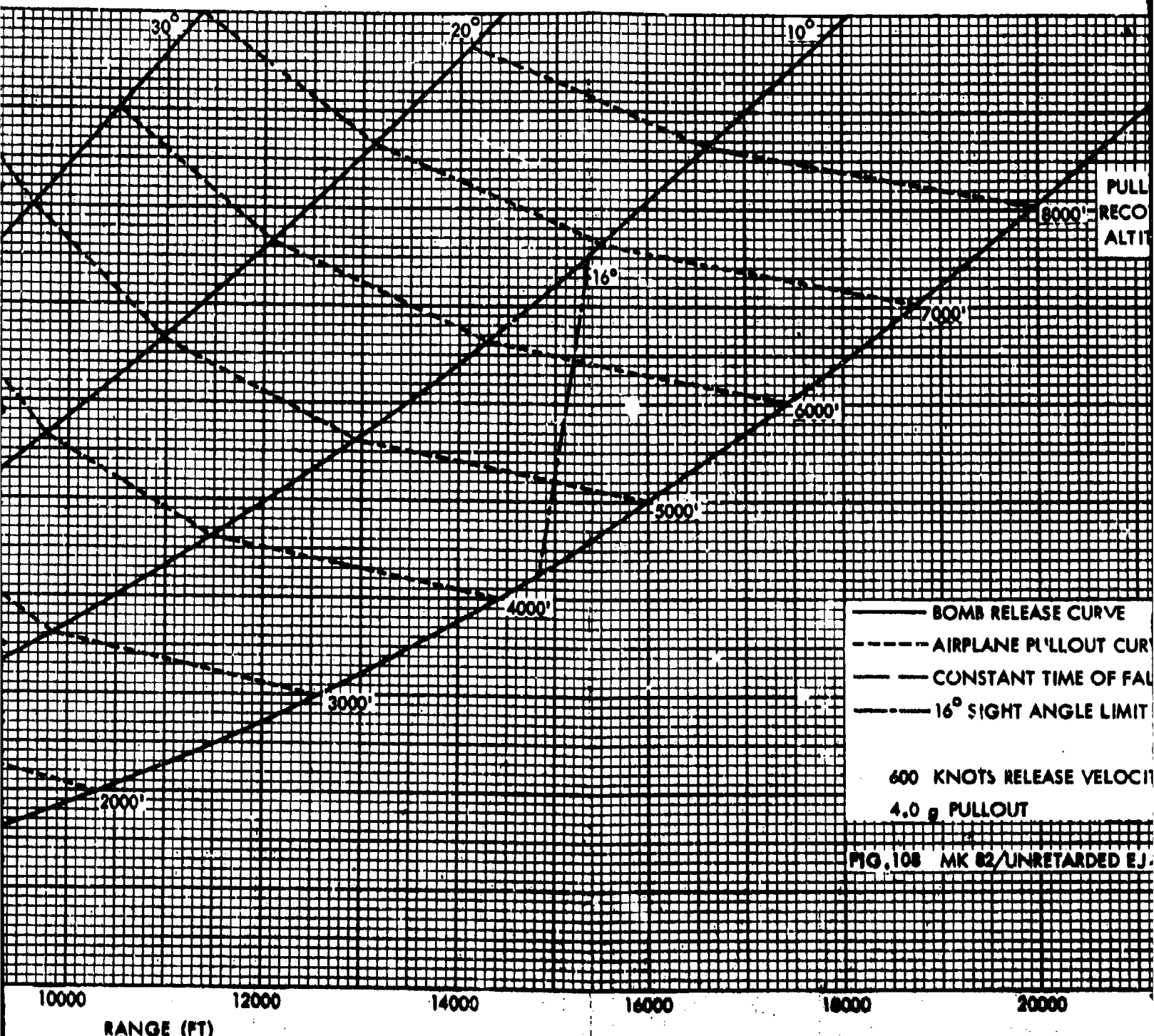
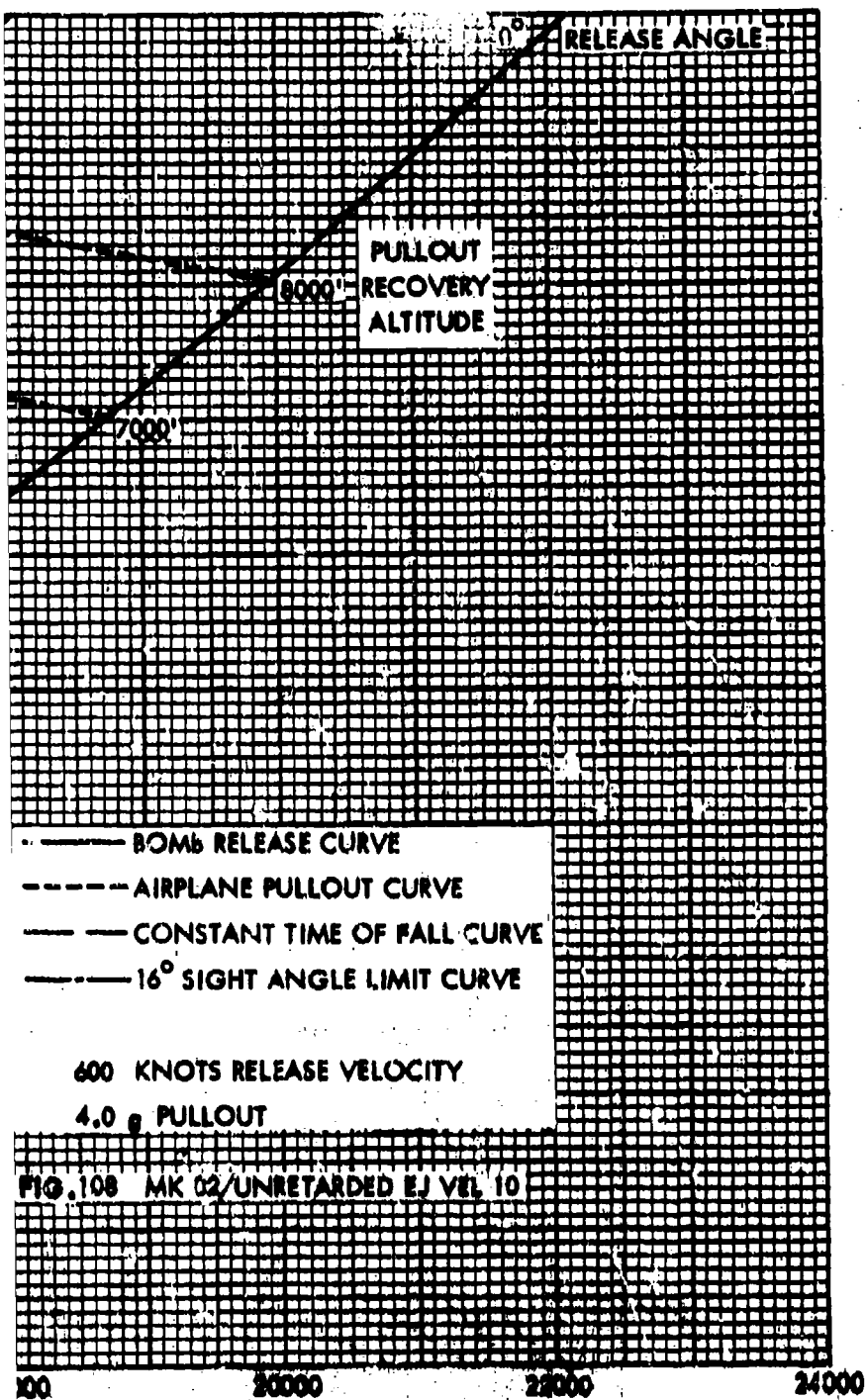


FIG. 108 MK 82/UNRETARDED E.J.



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<p>A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.</p>		

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